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TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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Number Eighteen

MEETING OF MAY 19, 20, 21, 22, 1924

ROSCOE, N. Y.

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TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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Number Eighteen

MEETING OF MAY 19, 20, 21, 22, 1924

ROSCOE, N. Y.

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*Active Member.

CONSTITUTION AND BY-LAWS
of the
Society of Motion Picture Engineers

Name

1. The name of this association shall be Society of Motion Picture Engineers.

Objects

2. Its object shall be: Advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members.

Membership

3. The membership of the Society shall consist of Pioneer Members, Honorary Members, Active Members and Associate Members. A Pioneer Member is defined as one who was in the art as a principal fifteen years or more antedating the time of the organization of this Society; an Honorary Member as one who has been actively engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts for more than ten years; an Active Member as one who shall not be less than 25 years of age and shall be:

(a) A motion picture engineer by profession. He shall have been in the practice of his profession for a period of at least three years and shall have taken responsibility for the design, installation or operation of systems or apparatus pertaining to the motion picture industry.

(b) A person regularly employed in motion picture or closely allied work, who by his inventions or proficiency in motion picture science or as an executive of a motion picture enterprise of large scope, has attained a recognized standing in the motion picture art. In the case of such an executive, the applicant must be qualified to take full charge of the broader features of motion picture engineering involved in the work under his direction.

An Associate Member as one who shall not be less than 21 years of age, and shall be a person who is interested in or connected with the study of motion picture technical problems or the application of same.

Eligibility

4. Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members for Active Membership shall be recommended in writing by at least two Active members in good standing, and for Associate Membership by at least one Active member in good standing, and may be elected only by the unanimous vote of the members of the Board of Governors in session.

Applications

5. All applications for membership or transfer shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee shall be thirty dollars ($30.00) for admission to the grade of Active Member, and twenty dollars ($20.00) for admission to the grade of Associate Member.

The transfer fee from Associate to Active grade shall be the difference between the above mentioned entrance fees, or ten dollars ($10.00).

The annual dues shall be twenty dollars ($20.00) for Active Members and ten dollars ($10.00) for Associate Members, payable on or before October 1st of each year.

Active Members and Associate Members elected by the Board of Governors, prior to, or at the Spring meeting, shall pay the full annual dues, and those elected after the Spring meeting, and prior to the Fall meeting, shall pay half annual dues.

The dues for Pioneer Members shall be $250 and its payment exempts the member from all future dues.

The dues for Honorary Members shall be $100 and its payment exempts the member from all future dues.

Officers

6. The officers of the Society shall be a President, the Past President, two Vice-Presidents, a Secretary, a Treasurer, and a Board of Governors. The above named officers and four Governors shall be elected to their respective offices at the annual Fall meeting by a majority of autographed ballots of the members, and counted by a committee of tellers appointed by the President. All officers shall hold office for one year or until their successors are chosen, except the Board of Governors, as hereinafter provided, and the Vice-Presidents; one of whom latter-named shall be elected for two years and one for one year, and then one for two years, each year thereafter.

Governors

7. The Board of Governors shall consist of the President, the Past President, the Secretary, the Treasurer, the Section Chairmen, and four other Active members; two of which last-named shall be elected for a two year term, and two for one year, and then two for two years each year thereafter.

Duties

8. The duties of the several officers are those usually appertaining to each such office, together with such additional duties as may be prescribed by the Board of Governors.

The Treasurer shall be bonded in an amount to be determined by the Board of Governors.

Meetings

9. The regular meetings of the Society shall be held in such places and at such hours as the members may have designated at the preceding meeting.

A quorum shall consist of twenty-five or more voting members. Special meetings may be called by the Board of Governors when necessity therefor arises. Active members only shall be entitled to vote. The Board of Governors shall meet quarterly at such time and place as they may select. Special meetings may be called by the President when occasion requires, or upon the request of any three members of the Board of Governors, not including the President.

Publications

10. All matters of general interest deemed worthy of permanent record shall be published in serial volumes as soon as possible after each regularly called Members' meeting. A copy shall be mailed each member in good standing to his last address of record. Extra copies shall be printed for general distribution and may be obtained of the Secretary on the payment of a fee fixed by the Board of Governors.

Emblem

11. The emblem of the Society shall be a facsimile of a four-hole film-reel, with the Letter S in the upper center opening, and the letters M, P and E, in the three lower openings, respectively. In the printed emblem, the four hole openings shall be orange, and the letters black, the remainder of the insignia being black and white. The Society's emblem may be worn by members only.

Delinquents

12. Members who are in arrears of dues for thirty days after notice of such delinquency, mailed to their last address of record, shall have their names posted at the Society's headquarters which shall be the office of the Secretary, and notices of such action mailed them; and thirty days after such posting the members shall be dropped from the rolls if such non-payment has continued.

Annual dues for the succeeding year shall be paid prior to the annual Fall meeting, and only members in good standing, who shall have paid all dues to that date, may vote or otherwise participate in the meeting.

Suspension

13. Any member may be suspended or expelled for cause by a five-eighths vote of the Board of Governors; provided, he shall be given notice and a copy in writing of the charges preferred aginst him and shall be afforded opportunity to be heard ten days prior to such action.

Local Sections

14. Sections of the Society may be authorized in any State or locality where the Active membership exceeds 10. The geographic boundaries of each section to be determined by the Board of Governors.

15. Upon written petition, signed by ten or more Active members, for the authorization of a Section of the Society, the Board of Governors may grant such authorization if the necessary membership exists within the locality specified in the petition.

Meetings

16. Meetings of the Section shall be held at time and places fixed by the Section's Board of Managers.

Officers

17. Each Section shall nominate and elect a Chairman, two Managers and a Secretary. The Section Chairman shall automatically become a member of the Board of Governors of the General Society, and continue in that position for the duration of his term, as Chairman of the Local Section.

Election of Officers

18. The Officers of the Section shall be elected to their respective offices at the annual Fall meeting of the Section, by a majority of autographed ballots of the Active membership of the Section, and counted by a Committee of Tellers appointed by the Section's Chairman.

19. All Section Officers shall hold office for one year or until their successors are chosen, except the Board of Managers, as hereinafter provided.

Managers

20. The Board of Managers shall consist of the Section Chairman, the Section Past Chairman, the Section Secretary, and two Active members, one of which last named shall be elected for a two year term, and one for one year, and then one for two years each year thereafter.

Business

21. The business of a Section shall be conducted by the Board of Managers.

By-Laws

22. A Section may formulate By-Laws for its conduct, which shall conform with the Constitution and By-Laws of the Society, and with the policy of the Society, as fixed by the Board of Governors. Proposed By-Laws, when approved by the Board of Governors of the General Society may be adopted by a two-thirds vote, at a regular or special meeting of a Section; notification of such meeting, together with a copy of the proposed By-Laws shall be sent to all members of the Section at least 10 days prior to the date fixed for its holding.

Expenses

23. As early as possible in the fiscal year, the Secretary of each Section shall submit to the Board of Governors of the Society a budget of expenses for the year.

24. The Treasurer of the Society may deposit with each Section Secretary a sum of money, the amount to be fixed by the Board of Governors, for current expenses.

25. Other expenses than those enumerated in the budget, as approved by the Board of Governors of the General Society, to be payable from the funds of the General Society, must first be authorized by the Board of Governors.

26. A Section Board of Managers may authorize, and shall provide for the payment by local assessments of any expenses of a Section beyond those authorized to be paid from the general fund of the Society.

27. The Secretary of the Society shall supply to each Section all stationery and printing, aside from notices of meetings, necessary for the conduct of its business.

28. The Secretary of each Section shall send monthly to the Treasurer of the General Society an itemized account of all expenditures during the preceding month.

Meetings

29. The regular meetings of a Section shall be held in such places and at such hours as the members may have designated at the preceding meeting.

30. The Secretary of each Section shall forward to the Secretary of the General Society, not later than five days after a meeting of a Section, a statement of the attendance and of the business transacted.

Papers

31. Papers shall be approved by the Section's Papers Committee previous to their being presented before a Section. Manuscripts of papers presented before a Section, together with a report of the discussions, and the proceedings of the Section meetings, shall promptly be forwarded by the Section Secretary to the Secretary of the General Society. Such material may, at the discretion of the Papers Committee of the General Society, be printed in the Society's Transactions.

Membership

32. Should the Active membership of a Section fall below 10, or the average attendance at meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

33. All members and honorary members of the Society of Motion Picture Engineers in good standing, residing in that portion of any country set apart by the Board of Governors to be tributary to any local Section, shall be considered members of that local Section, and shall be so enrolled and they shall be entitled to all privileges that such local Sections may, under the General Society's Constitution and By-Laws, provide.

Constitution and By-Laws

34. Sections shall abide by the Constitution and By-Laws of the Society, and conform to the regulations of the Board of Governors. The conduct of Sections shall always be in conformity with the general policy of the Society as fixed by the Board of Governors.

Amendments

35. These By-Laws may be amended, altered or added to at any regularly called Members' meeting on a two-thirds vote by ballot of the members present at the meeting.

PRESIDENTIAL ADDRESS

Spring Meeting of the Society of Motion Picture Engineers

Roscoe, New York, 1924

Fellow Members and Guests:

IT AFFORDS me great pleasure to welcome you to this, the 18th regular meeting of the Society of Motion Picture engineers. Those of you who have had the good fortune to attend previous meetings know that they have invariably been occasions of both pleasure and profit; and I feel sure that this meeting will be no exception to the rule.

Looking back upon the development of this organization during the past eight years, we see continuous progress and growth. Our Society has been particularly free from those dissentions and disagreements which so frequently, in societies of this kind, retard progress and detract from the good feeling among the membership. We are to be congratulated that our membership consists of individuals of such high personal character and such unusual technical ability. The Society has accomplished a great deal toward the standardization of practice and the establishment of a recognized nomenclature. It has had powerful influence in promoting closer cooperation between the widely different elements of the industry and has stimulated research and investigation to a very marked extent.

Our published Transactions, which contain the technical papers that have been presented at our various meetings, and the sometimes voluminous discussions excited thereby, form a very comprehensive encyclopaedia of information relative to Motion Picture Engineering. In fact they are practically the only publications of any consequence in this particular field. I sometimes think we ourselves do not properly appreciate the quality and importance of these publications. We should indeed be proud that our Society has produced in the last few years such a valuable contribution to the literature of this field. Considering the past of the Society, therefore, there is very little which can be subjected to adverse criticism. We must not, however, be satisfied with past achievements and having advanced to our present state of well-being, it behooves us to look into the future and to so order our activities that the coming years may see a continuation of our growth and development.

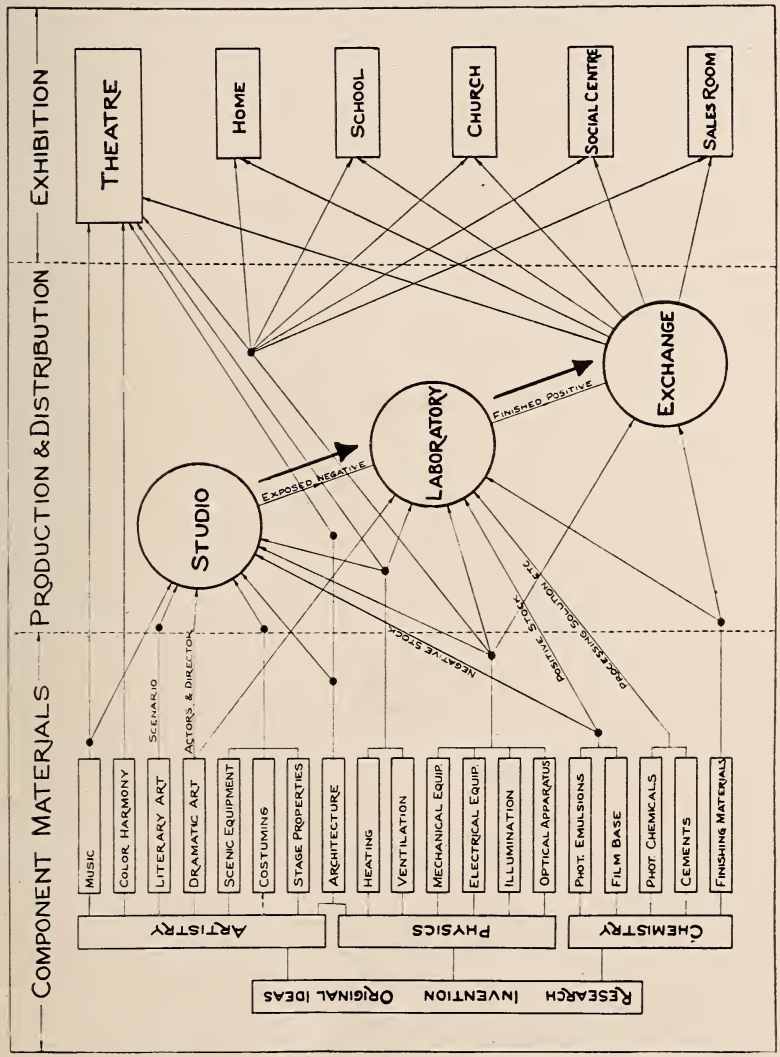
We have frequently heard the statement that nature abhors a vacuum and it seems to be equally true that nature abhors stagnation. There seems to be a fairly general natural law that in the case of vital organisms there must be either growth or degeneration. There

can be no standing still. This law, I think, applies equally well to organizations of individuals such as nations, states, churches, and societies such as our own. If we have the well-being and health of our Society at heart we must not allow ourselves to be lulled into a state of contentment and self satisfaction by our past achievements. If we hope to continue in a state of social health and vigor we must continue to grow, to expand our sphere of influence and to make ourselves more and more useful to the industry.

It may be well at this time to consider our position relative to the motion picture industry and to inquire as to the direction in which we may reasonably expect possibilities of expansion. Our activities already include a very large number of different phases and in those fields in which we are already interested, there is undoubtedly room for much farther valuable work. I do not mean to convey the impression that our only possibility of further growth is in expansion into new fields, but I do feel very strongly that we can hope to reach our highest plane of usefulness only by including all of those activities embraced in the motion picture industry.

As the name of our Society implies, we are an engineering organization, and I have sometimes felt that the word "engineer" has rather discouraged certain types of individuals from being interested in our work. If this is the case it is because the word "engineer" is interpreted by these people in its older and narrower sense. It will be found that the word "engineer" originally applied to one engaged in the operation of an engine. This meaning, of course, was given to the word many years ago and since that time its meaning has been very greatly broadened. In a dictionary published several years ago, I find that "engineering" is defined as "the art and science by which the mechanical properties of matter are made useful to man in structures and machines." Since the publication of this definition, however, the word has undergone further broadening and at the present time it is applied to many other lines of activity than those indicated in the definition above. We frequently hear of efficiency engineers, purchasing engineers, etc. The efficiency engineer certainly deals with many things other than the physical properties of matter. He deals with the psychology of the employee and with many subjective phenomena. It is evident therefore, that the term "engineer" has been broadened so that it now designates the practical application as distinguished from theoretical work and research in pure science. It is not even limited to the application of science but includes also the application of such things as psychology and if it is justifiable to include as "engineering" the application to practical purposes of psychological data it surely is justifiable to extend its meaning to include the application of art. If we accept this broader definition of the term "engineering," there is no reason why those who contribute literary, dramatic, and artistic talent to the making of a motion picture should not be interested, and vitally interested, in the activities of our Society.

Being a firm believer in the efficiency of visual methods for the conveyance of information and ideas, I have attempted to show graphically the inter-relation between the various elements composing the motion picture organism.



This chart you will note is divided into three parts as designated by the captions at the top. In the first are placed designations of the component materials which go into the production of a motion picture

the second part includes the production and distribution and in the third is indicated the consumption of the finished product.

The lines which connect the various inclosures indicate in a general way the points in the process of production, distribution, and exhibition, at which the various "component materials" are introduced. It will be quite impossible in a diagram of this kind to show in detail all of the complicated inter-relations which actually exist. To attempt to do this would make the diagram so complicated as to defeat its real purpose, which is to present a rather clear and general conception of the inter-relations existing between the various phases.

Let us now consider briefly the more important of the "component materials" which go into the production of a motion picture. For convenience these may be grouped as derived from three main sources (a) Chemistry (b) Physics, and (c) Artistry. This last term, while not entirely satisfactory for the conveyance of the idea in mind, seems to be more satisfactory than any other available. It is used to include all of those components of the motion picture which are essentially artistic as distinguished from materialistic.

To the motion picture "Artistry" contributes music and color harmony (by which I mean the use of color for the creation of atmosphere in the exhibition of the finished picture and includes the use of color produced by the application of coloring materials to the stage setting or the use of colored light either static or mobile). These components are contributed to and used very largely in the theater where the motion picture is exhibited, although music is very frequently used for the creation of the proper emotional atmosphere in the studio or on location where the play is being enacted before the camera. It seems probable now that in the future motion picture color will play an increasingly important part. There is at the present time a great deal of work being done in the development of color motion picture photography. As this new phase develops, color and color harmony must assume a much more important role than in the past. A new art of composition must therefore be developed in the studio. While at present the scene is suitably composed for rendition in black and white, in the future, great attention must be paid to the color composition. For this purpose, the artist who is master of color harmony must be employed.

To "artistry" we must go for the literature upon which is based the scenario, and for the scenarios themselves. Artistry contributes also dramatic art and is represented in the studio by the actors and director. The director's activity extends also, to a certain extent, to the laboratory where the scenes taken in the studio are edited and assembled into the final reel before sending to the exchange. Artistry contributes also the design of scenic equipment, costumes, and stage properties and the artists who work in this field are of great importance to the success of the production.

Architecture contributes its share to the activities in the studio. You will note that architecture as shown in the diagram is indicated as dependent upon both physics and artistry. As a matter of fact, the architect himself must have training in both physical and artistic fields. The architect contributes largely to the theater and at this point I feel sure there is an opening for our Society to do some very good work. We certainly should encourage the architects who are engaged in the construction of theaters for the exhibition of motion pictures, to become more familiar with the particular problems of properly placing before the public the product of this industry.

It is apparent from a consideration of the chart thus far that art contributes very largely to the production of a motion picture. The individuals representing this phase of the work, while they cannot be expected to be entirely familiar with all of the physical and chemical details of the process, should at least have some understanding of the physical nature of the medium by which their emotional feelings are to be conveyed to the public. If they can be given a more complete understanding of the possibilities and the limitations of this medium, certainly their art can be expressed more satisfactorily.

Continuing now with the consideration of the diagram we find that the science of Physics contributes very generously to the production of the motion picture. The heating and ventilation of the studio, theater, and laboratory must be handled by men trained in this science. Complicated mechanical equipment is required at many points in the process of production. Mechanical equipment is necessary for the proper adjustment and control of the illumination and for obtaining the various effects called for by the director. Mechanical ingenuity is called on for the design of cameras and other accessories used in the studio. The processing machines, printing machines, and projectors used in the laboratory and theater involve the use of many mechanical features and require the services of expert mechanical engineers in their design and construction. In the non-theatrical field, the apparatus which is used for the taking and projection of the pictures involves mechanical, optical, and electrical components.

Electrical equipment is required at almost every point in the production and exhibition of the motion picture. Elaborate electrical lighting equipments are used in the studio and on location. The laboratory depends very largely on electricity for many of its processes. Electrical equipment of many kinds are required in the theatrical exhibition of the finished product and in the non-theatrical field of this industry, many electrical devices are essential. A detailed enumeration of the application of electricity would require many pages of text and I am sure that with the suggestions as shown by the lines of the chart, it will be very easy for each of you to supply for yourselves further details.

The optical apparatus used includes lenses, projectors, reflectors, etc. It will be seen, therefore, that the science of Physics contributes very largely to this industry.

We must go to Chemistry for the photographic sensitive materials upon which this great industry depends. The photographic emulsion carrying the sensitive silver halide and the flexible cellulose nitrate and cellulose acetate bases upon which these emulsions are coated are all products of this science.

To the studio, chemistry contributes negative stock, and to the laboratory, positive stock and processing chemicals, such as developers, fixing baths, tinting and toning materials, etc. To chemistry also we must go for such materials as cements, cleaners, waxes for polishing, and many other things used in the studio, laboratory, and exchange.

This brief outline, I hope, will serve to give you a general idea of the many different phases of both science and artistry which are called upon for their contributions before the finished motion picture is placed on the screen in the theater or home, for the entertainment or education of the audience.

At the extreme left of the diagram you will note that I have an inclosure indicated as "research, invention, and original ideas." From this source the component materials available for the production of motion pictures is steadily being increased. We may regard this as the fountain head for all of the materials used in this industry. Research, invention, and literary creation are continually producing new processes, new machines, new methods, and new emotional combinations. It is to this source that we must look for the future advances in our work. I do not wish to convey the impression that research and invention are completely divourced from the studio and laboratory; as a matter of fact, research and invention are continually going forward in these places. Demands arise in the production departments and these demands, going out through the research worker and into the research laboratories, result in new ideas and new inventions. The groupings shown in the chart are adopted only to emphasize the inter-dependence of the various phases of work.

This Society should realize very fully that continued progress in research is of vital importance to the future development of the industry. The word "research" is here used in its broader sense to include all original investigation and creative effort. No opportunity should be overlooked to encourage, stimulate, and extend work of this kind. At the present time there are many things of interest in what we may term the embryonic or research stage of development. As illustrative of these may be mentioned: The reproduction of sound by photographic methods, which some day may result in the production of motion pictures accompanied by speech, music, and all the acoustical phenomena usually associated with the scene being reproduced; the transmission of motion pictures by cable and radio; stereoscopic motion pictures; motion pictures in natural color; etc. Motion pictures in color is an example of a new contribution from research, which at the present time is just emerging from the research stage and is beginning to become of practical importance. These are

only a few of the more obvious problems at present before the research worker and it would be quite futile to attempt to predict the nature and magnitude of the results which we may expect future research and inventive effort to yield. I think, in speaking to this audience, that there is little need to emphasize further that this field of activity is one to which our Society should continue to give its careful attention.

Turning now to the consideration of the production and distribution phase, we see that in the studio, the contributions of artistry, physics, and chemistry are thrown into the melting pot and under the supervision of the director, stage manager, camera man, etc., an exposed negative is produced. This is sent to the Laboratory where it is processed, resulting in a finished negative from which trial prints are made and inspected in the screening room. The work of cutting, editing, and assembling then begins and after many trials and tribulations, a finished negative is produced, from which the required number of positives are printed and sent out to the exchanges. From the exchange, this finished product goes to the theater, the home, the school, the social center, and the sales room. This diagram should not be interpreted too literally; for instance, the studio as represented here may not be the conventional indoor studio, but may include exterior locations and in fact any place where motion pictures are taken.

I think you will all realize from the consideration of this chart that the motion picture organism is extremely complicated, including as it does, personalities and individuals differing widely in type and temperament. Under such conditions, it is but natural that the worker in one field is prone to regard his particular part as the most important. The star and the director may be inclined to think that their's is the most important and most vital part of the organization. The photographic chemist who makes the emulsion upon which the picture is taken may feel that his contribution is most vital. The electrical engineer who provides the illumination in the studio where the pictures are taken is quite justified in thinking his contribution is of great importance. The projectionist, whose task it is to put the picture on the screen, may feel that his part is of the greatest importance, since, if it be not well done, all of the painstaking care of those who have participated in the production of the perfect positive (perfect from both the technical and artistic standpoints) will be of no avail. Each one is right in believing that his contribution is important, but the clear-thinking, fair-minded man must realize that his work is only a part of a long and complicated process, and that every step is of vital importance. Each individual who takes part in the production of the picture is only a link in the chain and, as has frequently been said, the strength of a chain can be no greater than that of its weakest link.

It is sometimes dangerous to attempt to draw analogies, but if we keep in mind that such comparisons must not be carried too far they

may be very useful in the illustration of ideas. Let us liken the motion picture industry, therefore, to the human animal having physical, spiritual, intellectual, and emotional attributes. In our motion picture organism we may then say that artistry represents the spiritual, emotional, and intellectual phases, while chemistry and physics correspond in a general way to the purely physical nature. The well developed, normal, and healthy human animal must be equipped with a healthy body, a well cultivated intellect and a properly developed emotional nature. The mind cannot function properly in a diseased and ill nourished body. On the other hand, a perfectly healthy and vigorous physique is of little use without a properly developed intellect and emotional nature. So in this motion picture industry, those interested directly in the artistic and emotional phases should be very much concerned that a healthy condition of development and progress exists in those fields of science and engineering which must supply the physical necessities. The scientist and engineer, on the other hand, should realize that the chemical process, mechanical devices, and optical instruments which he invents and constructs are only a means or a vehicle for the presentation of information, ideas, and dramatic art to the audience. It seems almost self evident that the health and development of this complicated motion picture organism must depend upon the proper functioning of every component organ.

An examination of our TRANSACTIONS will reveal the fact that most of our technical papers have dealt with subjects pertaining to the chemical and physical phases of the motion picture industry. We have had very little material from the artistic standpoint. We have not as yet succeeded in interesting to any extent the exhibitor, the producer, the director, and those concerned primarily with the field of artistry. It may be that we cannot hope to draw these people into active participation in the work of our organization; it does seem, however, that we should be able at least to induce them to take a greater interest in our activities than they have in the past. There is no doubt that anything which this society does to promote progress, growth, and development, reacts indirectly to the benefit of all those concerned in the industry. There are many phases of work very properly falling within our sphere of influence to which we have as yet given but little attention. There are many problems of vital importance on which but little work has been done. Looking into the future then, there seems to be no lack of opportunity for expansion, for there are many fields into which we have not as yet extended our activities, and in the fields in which we are already working there are many problems as yet unsolved.

I do not wish to impose further on the time of this meeting to analyze in greater detail the elements of this industry. I hope that these few, rather rambling remarks, may induce all of you to give this subject of our future growth and expansion, serious thought. I feel sure that you will agree that there is no evidence of our having reached

a state in our growth where further expansion is not to be expected. The field is very large and there are many problems as yet untouched. We have only just made a good start and I feel very confident in prophesying a future even more successful and fruitful than our past.

L. A. Jones

Roscoe, New York,
May 19, 1924.

THE PROGRESS OF ARC PROJECTION EFFICIENCY

By P. R. Bassett

THE illumination on the screen from a motion picture projector is dependent mainly on two things: the source of light and the method of utilizing the light from this source. This statement sounds, off hand, as though it gave opportunity for limitless discussion and tabulation of numerous light sources and optical arrangements; but a glance at the history of motion picture projection shows quite the opposite.

In the early eighteen nineties, when experimenters in all countries were struggling with the problem of making the newly-found motion picture practical enough for public exhibition, it was our own founder, C. F. Jenkins, who discovered the key to the problem. The original Jenkins projector, now in the United States National Museum, consisted of an optical system which first successfully projected motion pictures on a screen. This system consisted of a slightly inclined carbon arc as the light source, two plano-convex condenser lenses to concentrate the light on an aperture plate, and an objective lens to project the image on the screen.

For twenty-five years this simple and very practical arrangement held undisputed sway. From the earliest uncertain and flickering shows to the smooth and steady projection of the modern theatre, the equipment behind the projection head has remained fundamentally the same. Such improvements as higher amperage, better carbons, better condensers, etc. were made, but no radical change in system. When a device remains unchanged for so long, it is not necessarily a sign that it is unimprovable, but on the other hand, such stagnation is cause for suspicion. The reciprocating steam engine had reached just such a stage some years ago when the steam turbine suddenly arrived and pulled steam engineering out of the rut.

The last six or seven years have seen just such an awakening of interest in methods of projection. New light sources and new optical systems have been successfully applied in the last few years and have shown that there are great opportunities for improvement.

The carbon arc must now share the field with two other light sources: the concentrated filament incandescent lamp, and the high intensity arc. These are the three brightest sources available and compare as follows:—

Type of Source	*Light Emitting Element*	*Form*	*Absolute Temp.*	*Brilliancy, Candle-power per sq. mm.*
Incandescent Lamp	Tungsten	Coiled filament	3300° A	40
Carbon Arc	Carbon	Shallow crater face	4100° A	180
High Intensity Arc	Cerium Carbide	Mist and vapor in deep crater	5000° A	500

This variety of sources gives wide latitude of choice, but the incandescent lamp tends toward the smaller houses and the high intensity arc toward the larger houses. The carbon arc, however, is not being squeezed out between the two new comers, but, on the other hand, is strengthening its position to a great extent by recent improvements in optical systems. Each of these sources has certain inherent advantages and it is very unlikely that any one will be crowded out by the other two, although the efficiency of any or all may be materially improved optically.

Turning from the topic of light sources to the second consideration—that of utilization of the light, it will be found that here also recent years have produced radical changes and great improvements. The new aspheric condensers, the relay condenser system, the horizontal positive electrode in the high intensity lamp, and the improved objective lenses have all accounted for increased efficiency.

A few figures from some of my own measurements in the New York Strand Theatre, taken during the past seven years, will give an excellent idea of this progress:

Date	*Amperes*	*Light Source*	*Lenses*	*Screen Illumination*
1917	75	Carbon Arc	Plano convex	5 ft. candles
1922	75	High Intensity Arc	Plano convex	11 ft. candles
1923	115	High Intensity Arc	Plano convex	17 ft. candles
1924	115	High Intensity Arc	Cinephor condensers and objectives	26 ft. candles

The Capitol Theatre, New York City, shows the same sequence. My first measurements in 1921 showed a screen illumination of 5.6 ft. candles from a 120 ampere carbon arc. and standard lenses. 1922 with high intensity arcs showed 11.5 ft. candles. 1923 with 120 ampere high intensity arc and Cinephor lenses showed 15 ft. candles. In three years time the screen illumination in this theatre has increased to three times its original value.

In all of these figures, however, the increase in efficiency is utilized entirely for increasing the illumination on the screen. There is another and equally important angle to this question of increased efficiency and that is a reduction in current instead of an increase in light. The majority of theatre managers are not so anxious to multiply their screen illumination by three as they are to cut their current consumption by three. This phase of the question brings up one of the most recent and remarkable developments in optical systems—the Reflector Arc.

The Reflector Arc uses a concave reflector instead of condenser lenses to gather the light from the carbon arc crater and to concentrate it on the aperture plate. The use of arcs with reflectors is far from new. It has always been known that reflectors are more efficient than lenses in projecting light from such a source. Searchlights, headlights, and all such large efficient units use reflectors instead of lenses. It is, perhaps, surprising that reflector lamps did not enter the field of motion picture projection long ago. The fact is, there has been much talk but little action until recently, on this subject, and the few sporadic attempts in the past failed partly because of not being able to eliminate a black ghost in the center of the spot, due to the shadow of the carbons and carbon holders, and partly due to the tremendous inertia of the standard condenser system which had given satisfaction for so long.

Now that the Reflector lamp has finally overcome its inherent disadvantages and can project as clean a spot and as uniform a screen as a condenser system, the tremendous advantage in efficiency of the Reflector over the old type condenser is becoming apparent. The installations that are now being rapidly made are displacing 60 to 75 ampere arcs with 20 ampere Reflector Arcs, and 40 to 60 ampere arcs are being outdone by 15 ampere Reflector Arcs. It is interesting to see how such a tremendous gain is accomplished. I am going to attempt to show this by adopting a new method of demonstrating optical efficiency, which makes it possible to obtain a concrete mental picture of the light at all stages through the optical system. Light is one of the most difficult subjects to understand, mainly because it is not material and cannot be handled or easily visualized, as can material things.

In order for us to actually see what we are talking about, we shall convert the light into modelling clay, so that it can be handled and visualized. If a certain quantity of this clay is taken, the amount is measured in pounds, and no matter to what shape we mold it, the weight remains the same. The equivalent term for quantity in light is "lumens." Hence, the quantity of clay is proportional to lumens of light.

Although lumens are of great importance to the illuminating engineer, in practice we are more interested in light intensity, as, for instance, in projection work, the important consideration is the intensity on the screen. Light intensity is measured in foot candles.

The equivalent of foot candles in our clay models is the thickness or dimension to which we roll out a given quantity of clay. For instance, if we start with a pound of clay, we may either roll it into a long cylinder several feet in length, or flatten it out into a thin pancake a fraction of an inch in thickness. The length of the cylinder may be a thousand times the thickness of the pancake, that is, the foot candles would be as 1,000 to 1, although the lumens would be the same, for the same quantity of clay was used. A searchlight beam is a good example of the rolled out cylinder of clay, whereas, a very wide angled flood-light would be equivalent to the pancake of clay.

Before discussing the merits of the reflector type of lamp, it will aid us to consider the efficiency of the usual motion picture projection system with the standard condensers and arc lamp. By following with this clay light through the standard motion picture projector, the tremendous light losses may be clearly visualized.

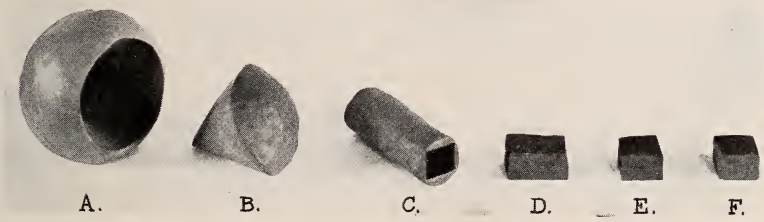


Fig. 1—Light Losses in Standard Motion Picture Projector.

Referring to figure 1, we will start with the light in the lamp house, from the positive crater of the arc. The lumens given by the crater are represented by the ball of clay about the size of a sixteen pound shot, (A and B fitted together). If the carbon crater is flat and symmetrical, the light given off by it would be represented by a true sphere tangent to the crater. This interesting fact in regard to the light distribution from flat light sources was discovered long before the days of the movies and is known as Lambert's cosine law. In the case of the standard carbon arc, however, the sphere is not complete, but has a deep dimple in it like that in an apple, caused by the shadow cast by the negative electrode, which intercepts some of the light from the crater. This shadow is cast downward in the standard arc and does not fall on the condenser lens. Hence, it does not directly affect the efficiency of the system. It is interesting to note, in passing, that with the modern carbon trims, the negative intercepts only about 8% of the lumens from the positive crater. This loss being directly at the bottom of A in figure 1 does not show in the photograph, but since it is only a loss within a loss it need not be considered.

As we know, only a portion of the crater light falls on the condensers, since the condensers usually take in an angle of about 60°. A 60° cone is cut from the sphere, as shown in B of figure 1. This cone represents the lumens gathered by the condenser lens. The large remaining shell A is the lumens lost in the lamp house and falling on the lamp house walls, is converted entirely into heat. It is no wonder that the ordinary lamp house is such an oven when 4/5 ths of the total wattage of the arc is converted directly into heat within the lamp house. Under the most favorable circumstances this used cone, B, may amount to 20% of the original sphere. In most cases, however, this cone amounts to only about 10% to 15% of the light from the arc. This variation in efficiency depends on the care of the operator in keeping his crater burned off at an angle facing the lens.

One quarter of the lumens in the cone B is the minimum loss by reflection and absorption in getting through the two condenser lenses. This loss is not shown separately in figure 1, but has been subtracted between B and C.

The next point that the light hits is the aperture plate, where it is converged to a small bright circle about an inch and a quarter in diameter. Following with the clay, we therefore take what is left of the cone after subtracting the 25% condenser loss and roll it into a cylinder an inch and a quarter in diameter. This now represents the lumens on the aperture plate. Here we meet another serious but unavoidable loss. Only a rectangle 1 inch by ¾ inches is utilized. The remainder of the circle is lost. This loss amounts to more than half of the light which falls on the aperture plate. Model C shows that this loss is quite large in lumens. Actually about 500 watts of energy are lost on the aperture plate. This is as much wattage as taken by an average electric toaster. It is readily understandable why asbestos aperture plates are needed. The light that passes through is the long rectangular block drawn out of the center of model C. This block was originally composed of D, E, and F in one piece. But in getting into and through the objective lenses, about 40% of this block is lost. This loss is shown by the piece D which was cut off from the long block drawn out of C.

The last shot that the projection machine takes at the rapidly dwindling lump of clay, or lumens, is the intermittent shutter which cuts the remaining block just about in half. Block E is the light lost by the shutter and block F, about the size of a chocolate caramel, is all that is left of the lumens to start for the screen. To carry this to the screen we must take the small remaining block F and roll it out into a sheet, say 18 x 15 feet. It is evident that the sheet would be very thin, probably about the thickness of a sheet of paper. This last little block is about 2% of the original ball in the lamp house. Therefore the optical efficiency of the standard projector is a maximum of 2%. In practice this figure is seldom reached. Dusty or pitted condensers, the wrong condenser combination, too large a

spot on the aperture plate, or any other of the numerous possibilities, has the effect of bringing down the efficiency to less than 1%. I have measured installations in fairly large houses and in all cases, have found the efficiency to be somewhere between 1 and 2%.

Anyone looking at these astonishing figures must feel that somehow, some of the 98% waste light could be saved. Looking back along the line of clay losses, it is evident that the most logical one to start on is the biggest, and that is the tremendous 80% loss in the lamp house. This is exactly the point where the reflector lamp has attempted to step in and boost the efficiency.

In this type of lamp, the condensers are replaced by a concave reflector 5 to 7 inches in diameter and about 4 inches focal length. It is possible with such a reflector, when properly ground and polished, to gather 75% of the light from the positive crater and focus it in a clean cut circle on the aperture plate.

This large gain in the percentage of light from the arc, which is gathered and thrown onto the aperture plate, is an advantage of 3½ to 1 in favor of the reflector lamp. In practice it has been found that the best way to utilize this gain is by reducing the current to about 30% of its value in a given condenser system. For instance, a 20 ampere arc in a reflector lamp is equal to a 75 ampere arc in a condenser lamp.

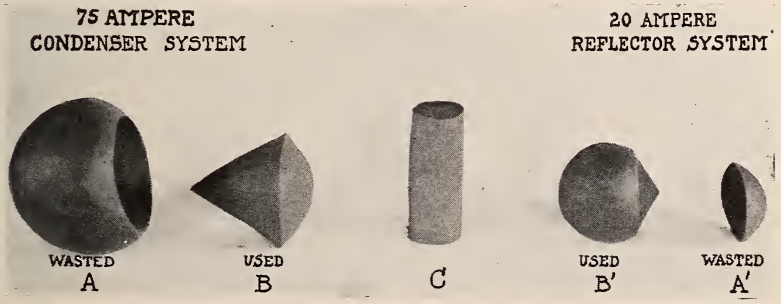


Fig. 2—Relative Efficiency of Condenser and Reflector Systems

Figure 2 represents the comparison in clay. The two models A and B at the left fit together to form a sphere, as do also the two models A′ and B′ at the right. The left hand sphere represents the lumens from the 75 ampere arc. The right hand sphere represents the lumens from the 20 ampere arc. The right hand contains only 30% as much clay as the left hand sphere. Now, as we have seen before, the condenser will use only the 20% cone of the large sphere, whereas the reflector will use the 75% cone of the small sphere, as shown in figure 2. These two cones, although of entirely different shape contain the same amount of clay, or in other words, have the same lumens, and either one, on the aperture plate, would take the form of the cylinder shown in the center of

the figure and hence would give the same light on the screen. This makes it evident how only one third of the lumens to start with can be made to put as much light on the screen as the old arrangement did with three times the lumens.

The fact that the current consumption is cut to 30% and the carbon cost is also reduced is sufficient to greatly interest the managers. The operator, however, will be interested in some of the other advantages. The most spectacular difference is shown in the two end models of figure 2. The big ball on the left is the heat in the lamp house with a 75 ampere arc, equivalent to 3½ kilowatts, converted entirely to heat. The small shell on the extreme right is a measure of the heat in the lamp house from a reflector lamp. It is only about 8% as much as in the condenser lamp, or about 280 watts, certainly no good as an oven, and therefore most desirable for the operator.

There are other advantages of interest with this type of lamp. The rheostat is less than one third the capacity of the standard one and hence gives much less heat and takes up almost no room. The generating equipment can be much more simple, as well as being much cheaper. The quality of the light is whiter with a reflector lamp than with the condenser system, partly because low current craters operate at a slightly higher temperature than high current craters, and partly because the light passes through less thickness of glass in the reflector system.

The best range of current for reflector lamps is from 8 amperes to 25 amperes. It is difficult to use efficiently more than 25 amperes, since the crater then becomes too large for the optical system. In other words, the spot on the aperture plate cannot be brought down to a circle an inch and a quarter in diameter and any larger circle from a larger crater only means more light lost on the aperture plate with no actual gain in light on the screen.

I have measured the light from at least five different types of reflector lamps. They vary considerably in efficiency. This variation in performance of the different lamps seems to depend mainly on two points: first, the design and accuracy of grinding of the reflector, and second, some form of automatic control, which will hold the electrode constantly near the focus. The advantage of an automatic feed on this small arc is that with an arc length of only about ¼ of an inch, small changes in the position of the carbon make noticeable changes in arc behavior and in the proper focus of the spot on the aperture plate. Maintaining an accurate focus is most important, due to the tendency of the black central ghost to appear in an unfocussed reflector arc. The operator should be relieved of having to constantly watch electrode positions.

The Stellarc Reflector Lamp shown in figure 3 gives a good idea of the arrangement of electrodes, adjustable reflector, and automatic control mechanism for mounting on the rear of the lamp house.

The largest immediate field for the reflector lamp is the medium

sized theatre which is now using from 40 to 75 amperes. These currents may be easily reduced to from 10 to 20 amperes. It is doubtful whether there can be any other single improvement in the optical system of the motion picture projector which can increase the efficiency to the extent that the reflector lamp has done.

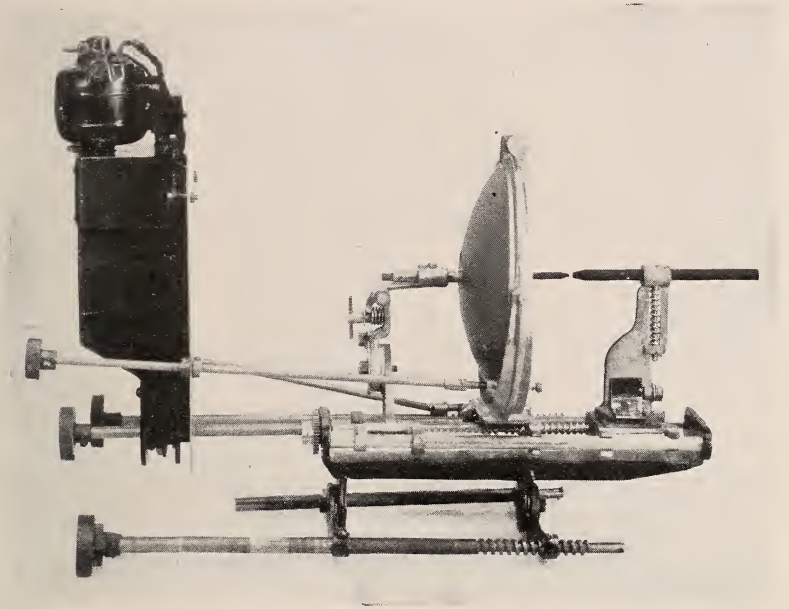


Fig. 3—The Stellarc-Automatic-Reflector Lamp

In summarizing, the efficiencies of the various light sources and optical systems which have been discussed in this article, the following table may prove helpful. It has always been found somewhat difficult to find a term which will allow of direct comparison of the different systems. In the case of arcs, where the voltage plays only a secondary part in light efficiency, and the amperage is all important, the author has found that a figure for "screen lumens per ampere" is most valuable and makes a broad and accurate method of comparison. This figure is easily obtained by multiplying the screen illumination in foot candles by the screen area in square feet and dividing by the arc current in amperes. The table gives approximately the range of screen lumens per ampere obtainable from the various combinations discussed. The figures have all been obtained by measurements of actual installations.

Light Source	*Optical System*	*Screen Lumens per Ampere*
Carbon Arc	Plano-convex condensers	12 to 20
Carbon Arc	Cinephor condensers and objectives	25 to 30
High Intensity Arc	Plano-convex condensers	32 to 40
High Intensity Arc	Cinephor condensers and objectives	45 to 55
Reflector Arc	Silvered glass reflector	60 to 100

DISCUSSION

Dr. Kellner: I think we should congratulate Mr. Bassett on this clever and elegant demonstration. Regarding the comparison between the reflector and relay condenser I feel that this is a question of quantity of light against quality. The gain in quantity by use of the reflector is easily offset by the evenness of illumination and by the far greater ease of manipulation, with the relay condensing system.

In judging losses at the aperture plate it should be remembered that for the same size of crater an increase of condenser aperture will cause an increase of loss at the aperture plate. This is also true for an increase in crater size when the condenser aperture is kept the same.

Mr. Richardson: There are one or two points I regret that Mr. Bassett failed to touch upon. One is the importance of crater distance—the distance of the light source from the face of the collector lens. We experience much trouble with this item. Any unnecessary distance from light source to face of collector lens involves a very great light loss, since the amount of light a collector lens of given area of free opening will pick up varies inversely with the square of its distance from the light source.

We have been obliged to use the minimum distance a crater of given amperage (arc lamp) can be kept from a collector lens without a too-great breakage as the basis for lens charts, but due to the fact that lamphouse ventilation is more or less clogged with dirt, or is not as ample as it should be from other causes, it has been necessary to use a crater distance in excess of what it ought to be and can be under right conditions. If it were given at its right value a large percentage of projectionists would be breaking a collector lens every reel they project.

Another thing: I have noticed the light from a reflector type of lamp is much whiter, more brilliant and pleasing than light which has passed through a condenser. I observed the same thing with the old Boylite Concentrator, which gave wonderful results but was too delicate in operation for practical use. In my opinion the decrease in screen brilliancy which Dr. Kellner intimates will take place as against a certain type of condenser will be more than compensated for in the increased whiteness and brilliancy of the light.

Mr. Gage: A point brought up by this paper is the distinction between efficiency and effectiveness. Effectiveness will produce a certain result. We do not care how many kilowatts of energy is used

so long as it will produce the desired results. Now, the result, the effectiveness of an optical system symplifies down to two things: There is an area of light from the machine as observed from the screen and the intrinsic brilliancy of the light source is diminished by the absorption of the lenses. That determines the effectiveness. The efficiency of the optical system is something that has to do with the ratio of the output of the system to the input of the system. The optical refinements do not increase the effectiveness of the combination but reduce the amount of in-put to produce the maximum result. That was demonstrated by the small section used to illustrate the mirror reflector. When changing from a 60 amp. arc to a 15 amp. arc on account of the increased efficiency, we must take into account the fact that the peculiar qualities of the high intensity arc are destroyed for the lower amperages so that we must take these factors into account. With the Mazda projection lamps, the tungsten wire is run at its highest intrinsic brilliancy. If we get an efficient optical system there is the practical problem that we cannot get at this highest brilliancy if the filament is made too short with the idea of taking advantage of the increased optical efficiency.

Mr. Palmer: Is it possible to get as high intensities with 20 amp. and small carbons as at higher amperages?

Mr. Egeler: I want to emphasize what one or two of the previous speakers have brought out, namely, the advantage of using models or other devices to illustrate technical data before an audience. I think the Society should encourage this form of presentation, so that our members can receive more from papers which include other than very simple technical data.

I agree with Dr. Kellner that the figure given for the loss of light at the aperture plate appears too low.

In connection with the figures given on increase in screen illumination, without wishing to minimize the improvements in arc efficiency which have been brought about, I would call attention to the practice of some theaters to use extremely high screen illumination intensities with correspondingly high brightnesses, especially for certain portions of the audience. With some of our modern motion picture theaters seating several thousand people, the problem is not simple when it is borne in mind that we should furnish a satisfactory brightness in the direction of people in the back of the auditorium who may be 150 feet from the screen, as well as for those in the front of the house who may be only forty or fifty feet from it. It is too often overlooked that in furnishing the highest desirable brightnesses for the rear observers those in the front of the house are continuously subjected to bad glare, and the net results may be far worse than if a moderate intensity were employed. In other words, with a considerable range in intensity of screen illumination which will be satisfactory, if the choice is between a moderate intensity and too high brightness for a portion of the audience, the moderate intensity should be selected. In theater practice, glare may cause far more harm to the

eyes than what many exhibitors consider is low illumination. Good screen illumination is not a matter of projecting as much light as possible, but of correctly distributing light in the directions of the observers in all parts of the auditorium, with due consideration to their position with reference to the screen and their distance from it.

Mr. Porter: Possibly Mr. Bassett plans to do it, but if not, I suggest that he has pictures taken of the model because they would be valuable in the Transactions.

Mr. Richardson: I suggest the reduction of these foot candle measurements on the different screens to a standard so that we can study the value of improvement in different theaters.

Mr. Kunzmann: In making the candle power measurements I should like to ask Mr. Bassett whether he used the hand photometer and how these compare with the candle power readings of a Sharp-Millar Photometer, where comparative readings were taken on the theater tests referred to.

Mr. Bassett: The table of lumens per amp. on the last page of my paper, I think covers the last point raised by Mr. Richardson.

The most difficult thing in the design of a reflector lamp system is to overcome its sensitiveness to adjustments; it is this which has postponed the arrival of the reflector lamp so long—that is the tendency to get a black spot or center in the picture when not accurately adjusted. It depends on the small size of the carbon holder and the proper curvature of the reflectors to minimize or eliminate this. More is necessary than the elimination of the ghost in just one position. The success of a good reflector lamp depends on the latitude of the adjustment without the appearance of a shadow in the center of the picture.

Mr. Kunzmann speaks of the photometer. We use a standard Sharp-Millar Photometer and get 2% accuracy rather than the less accurate foot candle meter.

Mr. Richardson brings up the point of a whiter light with the reflector than with the condenser system. The light passes through less glass in the reflector system, but the larger difference in light is due to the fact that a small 15 or 20 amp. arc runs with the crater temperature slightly higher than that of a higher amperage carbon arc. The higher the temperature of the carbon crater the whiter the light. This whiter light from the reflector lamp is very evident on comparative tests.

Dr. Gage brings up the point of effectiveness and efficiency. I did not take up this point in the paper. Most of the measurements I have cited were taken where the projection was considered satisfactory, and therefore I have been interested mainly in the efficiencies necessary to obtain satisfactory projection.

Mr. Palmer speaks of 20 amp. high intensity arcs for projector lamps. The margin of greater efficiency as compared with the ordinary carbon arc decreases rapidly with low current values. By

continual experiment the current was forced down to 50 amps. and we are now building one of 35 amps., but not for motion picture projection.

Mr. Griffin: Where does the efficiency of the reflector type of arc fall as the carbon size increases to take care of higher currents?

Mr. Bassett: It starts to fall at 18 or 20 amps., and the increase between 20 and 25 is no longer proportional to the current, beyond 25 amps. the increase is almost nothing.

COLORED GLASSES FOR STAGE ILLUMINATION

By H. P. Gage

Demonstration of Primary Colors

RESEARCHES in physiological optics have shown that the eye is sensitive to three primary color sensations and that the appearance of any hue may be produced by observing light containing one or more of these three primary color sensations. These primary sensations are red, (Fig. 1)[1]; green, (Fig. 16); and blue, (Figs. 11 and 12). Addition of the sensations of red and green gives the sensation of yellow, of red and blue gives a purple ranging from a very blue purple to a reddish magenta, and the combination of blue and green gives a blue green.

If two of the primaries such as red and blue are placed side by side in a lantern at the focus of the objective lens the two patches of color are observed side by side upon the screen with a sharp dividing line between. If now the glasses are moved out of the focus of the projection objective, so that the dividing line is blurred, a mixing of the two patches of color occurs and the blurred dividing line shows the mixed color which in the case mentioned consists of the characteristic series of purples, ranging from blue purple on one side to red purple or magenta on the other.

An object may appear colored by projecting suitable light upon it from three separate lanterns directed upon the object, one lantern equipped with red, one with green and one with blue. Varying the relative intensity of the light from each lantern, the object may be illuminated with any one of the primary colors, or by a combination of the primaries or, if the primaries are in exactly suitable proportion, the summation of the light will be white light and the object will appear exactly as it does in daylight. While theoretically this would be a neat way of obtaining any desired colored illumination it is rather wasteful and for practical purposes it is much better to choose a suitable color filter which absorbs no more than is necessary.

When working with pigments it has generally been assumed that the three primary sensations were red, yellow and green. The successful combination of pigments, as with the three color printing process, requires as the "red" pigment not the pure red of the spectrum but a magenta or red purple. Inasmuch as the apparent color of an absorbing medium, whether transparent or reflecting, consists of the light which falls upon the coloring material from which is subracted the light which the coloring material does not transmit or reflect as the case may be, a combination of two coloring materials will result in the combined absorption of each.

[1] Illustrations will be found on pp. 47-51.

The three absorbing primaries are: minus red, (Fig. 7), which appears blue green; minus green, (Fig. 25), which appears a magenta; and minus blue, (Fig. 3), which appears a lemon yellow. A combination of minus red and minus green superposed transmits only what light is not absorbed by either of them, i.e. it transmits blue. Likewise minus red and minus blue superposed transmits the common color, green; and lastly minus green and minus blue transmit red. Superposition of all three filters transmits no light. This last phenomenon is similar to one which can be illustrated by superposing the red and green filters, the green and blue filters, or the red and blue filters. Also, superposing the red and minus red, the green and the minus green or the blue and minus blue filters, no light is transmitted.

The colors projected upon the screen by use of the six colored filter glasses previously mentioned are readily observed by the eye. Other color filters are obtainable which transmit radiant energy not visible to the eye. To detect such energy requires other means than visual examination.

Demonstration of Radiant Energy

If we hold a piece of celluloid motion picture film, preferably of some dark object or a title, at the focus of an arc or Mazda projector condenser the radiant energy concentrated at the image of the light source is usually sufficient to cause the film to blister and catch fire. If now we cover the condenser with a piece of black heat transmitting glass (such as G554FF) no light is seen at the image of source. It will be found, however, that the film blisters and ignites although requiring somewhat greater time than in case the apparently opaque heat transmitting glass is not used. Thus we can demonstrate that the arc (or Mazda lamp) radiates a great deal more energy than is apparent to the eye, and this invisible infra red energy, when absorbed, results in intense heating. If instead of the heat transmitting glass a heat absorbing glass (Fig. 6) is used the film may be placed with impunity at the focus of the arc although a great deal of visible light is concentrated upon it. The success of this experiment of course depends upon sufficient energy being radiated by the arc or by the Mazda lamp to ignite the film and at the same time the intensity must not be so tremendous that even the visible part of the spectrum contains enough energy to ignite the film.

Not only is invisible radiation in the infra red emitted by the arc but also invisible radiation of shorter wavelength known as ultra violet which does not effect the eye to any appreciable extent. By placing a piece of ultra violet transmitting glass (Fig. 14) in front of the condenser such a beam of invisible ultra violet is easily obtained. A great deal of ultra violet radiation can be concentrated upon a piece of white paper with no visible effect or but a slight bluish spot of fluorescent light. If in place of the white paper there is used some substance which absorbs ultra violet and is rendered luminescent or fluorescent thereby, an intense glow is observed. Such substances as anthracene (preferably 90% resublimed rather than chemically

pure) or some salt of uranium such as uranium nitrate or sulphate, or uranium dissolved in glass such as fluorescent canary glass will absorb this ultra violet light and reradiate light of longer wavelength in the visible spectrum. Most fluorescent substances give off a faint blue or a bright green light. Light of a brick red color is caused by the fluorescence of rhodamine dissolved in celluloid.

By covering a spot light with a piece of ultra violet transmitting glass a strong beam of ultra violet is projected. In this beam many substances fluoresce and are capable of producing the most spectacular effect. Ordinarily persons are not visible in this beam of ultra violet, although if sufficiently powerful it will be noticed that teeth, eyeballs, finger nails and white hair fluoresce with a ghostly blue-white light. In an apparently well equipped mouth artificial teeth of porcelain or gold appear absent in contrast with the bright fluorescence of natural ones.

We will now turn to a careful examination of individual glasses which are capable of being used to produce the colored beams of light for spot-lighting, flood lighting, etc. and project their absorption spectra upon the screen. A projection lantern equipped with slit and prism may be used to project a bright spectrum upon the screen. It is well known that a prism bends light towards its thicker edge and that it bends radiation of short wavelengths to a greater extent than radiation of long wavelengths thus sorting out upon the screen radiation according to its wavelength. The effect upon the eye of the longest visible wavelengths is red. With shorter wavelengths come green, blue and violet. Radiation of greater wavelength than the visible red, called infra red, may be detected by the use of a sensitive thermocouple placed beyond the visible red and the invisible short wavelengths called ultra violet are made visible by the use of a fluorescent screen such as one covered with anthracene. If a triangular prism is used, then a mirror fastened upon the flat side of the prism can be turned in such a way as to give a spot of white light somewhere upon the screen so that the light of the source may be seen at the same time as its spectrum. A glass placed to intercept light concentrated upon the slit will alter the projected spot of white light and the projected spectrum so that it shows side by side what is ordinarily known as the color of the glass and also the alteration in the spectrum caused by the removal of a portion of it, thus enabling us to get a good idea of why the glass appears colored. In a printed paper it would be nice to have color plates of the spectrum but these are much more difficult to get than black and white cuts. The illustrations included in this paper are made with a wedge spectrograph upon which are marked the wavelength of the corresponding portions of the spectrum. In order to determine the color of the different parts of the spectrum it is safe to assume the following wavelength limits for the different colors.

Ultra violet	less than	.400μ
Violet	.400μ —	.435μ

Blue	.435μ	—	.490μ
Green	.490μ	—	.574μ
Yellow	.574μ	—	.595μ
Orange	.595μ	—	.626μ
Red	.626μ	—	.720μ
Infra red more than	.720μ		

The transmission of different colored glasses may be shown in the form of spectrophotometric curves, i.e. curves showing the exact proportion of incident light of each wavelength or portion of the spectrum. Spectrophotometric transmission curves of a great variety of glasses are shown in the Technologic Paper of the Bureau of Standards, No. 148, for the ultra violet and visible portions of the spectrum. For the visible and infra red portions of the spectrum consult Scientific Paper of the Bureau of Standards, No. 325. Color filters may be divided into four groups according to the portion of the spectrum which is transmitted: First, those in which the shorter wavelengths are removed; second, those in which the longer wavelengths of the spectrum are removed and the shorter transmitted; third, those in which both ends of the spectrum are removed and the middle is transmitted; and fourth those in which both ends of the spectrum are present and the middle is removed.

Glasses Transmitting the Long Wavelength Portion of the Spectrum, Absorption of the Short Wavelengths

Infra red transmitting glass—G554FF.*

A glass transmitting infra red radiation but opaque to visible light was demonstrated in the experiment of setting fire to the film.

Red—Fig. 1—Selenium red, G24.

A good red glass transmits only the red end of the spectrum and removes all radiation of shorter wavelengths. A poor red transmits other colors also. The gold ruby, Fig. 25, is really a red purple and while desirable for some purposes should not be confused with a true red.

Selenium orange, Fig. 2. G34.

A series of glasses having abrupt spectral cut-off ranging from deep red to pale straw color are called the "Selenium Series." There are innumerable shades of orange between red and yellow which differ by a slight shift in the position of the end of the spectrum. The yellow appearance is caused by a mixture of red and green, the exact shade of orange or yellow depending on the proportion of the two color sensations present. Orange and yellow glass may have a gradual instead of an abrupt spectral cut-off as in the case of numerous shades of amber such as shown in Figs. 18, 20 and 21. With most amber-glasses not only is the spectral cut-off gradual but the glass is

*These glass numbers, G554FF, G24, etc., are used by the Corning Glass Works to designate the particular glass described.

inclined to be muddy and have considerable absorption for those portions of the spectrum which should be transmitted.

Lemon Yellow—Noviol, G38H, Fig. 3, Fig. 29A

If the blue only is removed from the spectrum the result is a lemon yellow. Removal of this blue may be abrupt as in the case of Noviol or gradual as in the case of pale amber, Fig. 18, having nearly the same color, or it may be in two steps as in the case of canary glass, Fig. 19. In all three cases the color of the glass appears about alike and the average position of the blue absorption is nearly the same, about .46μ.

Pale amber, G30B, 1.5 mm. thick, Fig. 18.

The spectral cut-off in the blue is gradual instead of abrupt. Compared with Noviol C the color appears slightly pinkish and changes to a greater extent according to the light source used.

Canary glass, G371AR, Fig. 19.

The spectral cut-off is in two steps; there is a complete cut-off at .44μ, a blue transmission band at .46μ, an absorption band at .49μ and nearly complete transmission at greater wavelengths than .50μ. In a greater thickness the absorption is complete for .50μ and the color is more orange. In lesser thickness another transmission band appears at about .38μ.

An interesting property of canary glass is its bright fluorescence when illuminated with blue or ultra violet radiation. A particularly fluorescent canary glass is G371R. This glass has a pale yellow color as seen by transmitted light but ordinarily it fluoresces so brightly that it appears a yellow green.

Noviweld shade 3, Fig. 20.
Noviweld shade 6, Fig. 21.

Noviweld glass is an example of a dark amber. The ultra violet and blue are absorbed. Also this glass removes the infra red as can be demonstrated by measuring the transmitted heat radiation. The particular use of this glass is in the form of goggles and other eye shields for use when welding with the arc or with oxycetylene torch. The projection engineer should find this glass useful for windows of arc houses, etc. Noviweld is shaded according to its transmission for the yellow light of the sodium flame. Shade 3 transmits 20% of this light. Shade 6 transmits 2%, shade 8—0.5%, shade 10—0.1%, shade 12—.02%, suitable for observing arc lamps, and so on.

Noviol O, G38L, Fig. 4, Fig. 29C.

This glass removes ultra violet of shorter wave lengths than .38μ yet appears of a pale straw color and has but a slight absorption for visible radiation. This glass is useful for protecting the eyes from the ultra violet of the sun and of arc lamps when used either as goggles or enclosing glassware for arc lamps.

Clear, Fig. 5.

Some of the apparent irregularities in the spectrum are caused by irregularities in the sensitiveness of photographic plates to different spectral regions. It is therefore desirable to have a spectrum taken without any colored glass for comparison. It will be noted that the limits of the spectrum shown are .38μ in the violet and .72μ in the red. The blue end is caused by absorption of glass parts of the spectrograph and the red end is the limit of sensitiveness of the particular plate used. If either end of the spectrum is clipped off shorter than this it indicates absorption in the corresponding portion of the spectrum.

Absorption of the Long Wavelengths

Heat Absorbing Glass, G392H, G124J, Fig. 6.

Has a pale blue green color and reduces the red end of the spectrum. In the infra red just beyond the visible the absorption is complete. This glass is useful for preventing films and slides from becoming overheated while being projected.

Blue Green Glass, G403 ED, Fig. 7 and G584J, Fig. 29H.

Removing more of the red end of the spectrum there results a blue green.

Theatre blue, light shade, Fig. 8, dark shade, Fig. 9.

Removing more of the red end of the spectrum and part of the green there results a greenish blue in the case of the light shade and a light "sky" blue in the case of the dark shade. These are types of color not heretofore obtainable in glass and represent a new development in the art. These two shades appear so far to be the best shades of blue for theatre use for, while a purer blue can be produced as in Fig. 11 by removal of all green light (longer than .49μ), the luminosity of the pure blue is so low that with the ordinary spot or flood light the object would scarcely appear illuminated at all.

Signal Blue, G50, Fig. 10, is an example of the older type of blue glass. The blue is contaminated by a band of blue green at wavelength .56μ; while this blue green has but a slight transmission its luminosity is high and the color appears less pure than the dark shade of theatre blue, Fig. 9, which does not pass blue green. The signal blue can be distinguished from the blue purple, Fig. 24, by observing it through a red glass. Signal blue does not transmit red light to any extent while blue purple does.

Dark Blue, G54, Fig. 11, differs from signal blue in that the .56μ band of blue green is absorbed. It is rather dark for theatre use but is useful when a pure blue is needed.

Violet, G53C, Fig. 12, transmits only violet and part of the blue. The sample shown is thin. A thicker piece is darker.

Blue purple ultra, G585M, Fig. 13, Fig. 29-I. This glass appears much like the violet glass, G53C, but it also transmits a band of extreme red about .72μ which shows in the original negative but not

in the reproduction. This red band is similar to that shown by blue purple, Fig. 24. When it is necessary to suppress the red band this glass can be combined with a thickness of light blue green ultra, G584J, Fig. 7, Fig. 29H. The particular virtue of this glass is that it absorbs the greater portion of the visible light without impairing its great transparency to the ultra violet, as shown in Fig. 29-I.

Red purple ultra, G586A, Fig. 14, Fig. 29J, transmits extreme red in the neighborhood of .72μ, not shown in the print, and extreme violet and ultra violet. It transmits but little visible light and appears dim violet with an arc and dim red purple with a Mazda source. With the Mazda source it is often desirable to suppress the red band which may be accomplished by the use of a layer of pale blue green, G584J. It will be noted from Fig. 29 that the G584J transmits as far into the ultra violet as the G586A.

Violet Ultra, G586AW, 8.5 mm, Fig. 29K, transmits a limited region of ultra violet but no light in the visible portion of the spectrum

Absorption of Both Ends of the Spectrum

Glasses which absorb both ends of the spectrum are green. If in addition to absorption of blue, such as with orange glass, Fig. 2, there is absorption of part of the red; the result is a greenish yellow. If all of the blue and all of the red are absorbed the result is a pure spectral green or "grass" green, if all of the red and but a slight amount of blue is absorbed the result is bluish green such as is used in railway signals. Green filters can be built up by combining a suitable depth of blue green with one of the selenium series yellows.

Greenish yellow, G311AW, Fig. 15. All of the blue and some of the red is absorbed.

"Grass" green, G401CZ, Fig. 16. Most of the blue and all of the red is removed.

Signal green, G40D, Fig. 17, all of the red is absorbed and the blue is slightly reduced. The color differs slightly from the full blue green illustrated in Fig. 7.

Absorption of the Middle of the Spectrum

The grouping of the glasses according to spectral type has been changed slightly in order to bring glasses of similar use or appearance together. Thus blue purple ultra and red purple ultra have been grouped with the blue glasses in spite of the slight transmission band in the extreme red end of the spectrum.

Daylite glass, G90A, Fig. 22, is a blue type glass but is introduced at this point to contrast it with the purple type glasses. Daylite glass is made with such coloring agents that it will transmit all of the blue but will absorb the excess green and red of the gas filled Mazda lamp in the proportion necessary to give a spectral distribution duplicating natural daylight.

Lunar white, G57, Fig. 23, is a purple type glass. The density of color is so chosen that it filters the light from a gas filled tungsten

lamp so that the appearance is nearly the same as natural daylight. This white appearance is due to a close balance between the red, green and blue color sensations. The result differs materially from that produced by the Daylite glass or by natural daylight as can be determined by spectrophotometric analysis. Comparing the Lunar white with natural daylight, it will be found that there is an excess of red light at the extreme end of the visible spectrum between .68μ and .72μ to make up for a difficiency of red and orange between .57μ and .68μ. Other irregularities in distribution occur and as a result the colors of objects other than white are greatly distorted.

Light Blue-Purple, Fig. 24.

Both ends of the spectrum are transmitted. There is absorption between .58μ and .68μ. The general appearance is blue similar to the signal blue, G50, Fig. 10. This is the general type of glass ordinarily sold as blue. Most sheet blue glass obtainable in the market is of this nature and is really a blue purple instead of a true blue. The red light transmitted is likely to result in an appearance of red upon cheeks, lips, etc. when people on the stage having considerable make-up are illuminated by this light. The use of a blue purple alternating with a true blue of nearly the same general appearance gives a chance for subtle changes in illumination effects. The general appearance is somewhat "warmer" than when a true blue is used.

Gold ruby, Fig. 25, varies from a flesh pink to a red according to density.

Royal purple, Fig. 26, a more magenta shade of purple owing to general absorption in the yellow and red is characterized by an absorption band in the green between .48μ and .56μ. Gold ruby in low density should be of value in stage lighting as its pink color gives a warmth of tone to everything illuminated by it. This flesh color pink is not illustrated here because the absorption is only partial and the spectrum photograph was indistinguishable from Fig. 5 clear.

Amethyst, Fig. 27, is a magenta color with greatest absorption between .48μ and .54μ. There is a general absorption throughout the spectrum as can be readily seen in the photograph. The result is muddy so that illumination is cut down unnecessarily.

"*Gray Surprise,*" G555P, Fig. 28, and "*Pink Surprise,*" have but little apparent color. The "Gray Surprise" is practically neutral in tint and appears gray. The "Pink Surprise" appears a light flesh tint. The spectrum of both appears almost exactly the same having a narrow sharp absorption band which completely removes the yellow from the spectrum. In addition there are several absorption lines in the blue and the green.

These glasses are useful in the chemical laboratory for spectrum analysis as the sodium line in a flame test can be completely removed when looking for small amounts of lithium, potassium and other salts in the presence of a high percentage of sodium. It is used to some extent to modify the light of the mercury arc by removing the yellow lines and enabling the isolation of the green line of that source.

In theatre work these glasses give pleasing and startling effects. Used in front of a spot light the general effect is to slightly increase the "warmth" of the surroundings without modifying their color. Let someone walk into the illuminated area and the natural pink color of the complexion is greatly heightened so that make-up becomes unnecessary. The effect of the use of these glasses might be called "plastic make-up." If it is desired to change from a pleasing to a gruesome aspect it is only necessary to substitute a pale blue green glass, such as heat absorbing glass and instantly all complexions fade to a ghastly paleness. The heightened complexion color can not be obtained easily with any other filter. The use for example of a thin flesh colored gold ruby will give a general pinkness of tone to faces and background alike but the "surprise" glasses add warmth to the complexion without much altering the background.

Ultra Violet

Of considerable interest to the projection engineer and the photographer is the behavior of glass in the ultra violet.

Serious ultra violet burns result from the use of arc lamps, such as white flame arcs, quartz mercury arcs, iron arcs produced for electric welding and to a certain extent from the sun. Ultra violet treatment is used for the cure of rickets and tuberculosis. The physiological effects of the ultra violet, both harmful and beneficial, are prevented by enclosing or screening the light by suitable glassware. Ultra violet in the region of .3μ to .31μ appears to have the greatest physiological effect and is removed by all but the most transparent glasses. The effect of the medium range ultra violet is less definite but even ultra violet of wavelength .35μ is regarded with suspicion. The chemical effects of ultra violet such as for example the deterioration of rubber, the fading of dyestuffs, etc. seem to be less marked the longer the wavelength. The photographic effects of light with ordinary emulsions seem to be greatest in the blue rather than the ultra violet. For efficient photography the ultra violet may thus be eliminated if it seems desirable to protect the actors from the harmful effects of the ultra violet when arc lamps are used. This may be done by proper choice of enclosing glassware.

The ultra violet spectrum of the iron arc after being transmitted through various glasses is shown in Fig. 29. The wavelength of the limits of transmission are marked. With the first eight glasses; the left or long wavelength end of the spectrum strips are due to the end of the sensitiveness of the plate. With the first glass only a few blue green lines show; the red and green lines did not "take."

A.	Noviol "C" Lemon Yellow,	cut-off .480μ	between green and blue
B.	Noviol "A" pale straw color	cut-off .408μ	between violet and ultra violet
C.	Noviol "O" 3 mm pale straw color	cut-off .38μ	
D.	G385 DP 3.4 mm slightly greenish	cut-off .367μ	A practical glass for ultra violet absorbing enclosing glassware

E. Ordinary window glass 2.7 mm
slightly greenish cut-off .34μ
F. Plate glass 2.8 mm selected for transparency, slight tinge of green as seen from edge cut-off .32μ
G. PYREX 2.85 mm practically no color as seen from edge
cut-off .31μ

This is the glass to use where ultra violet transmission is desired. For the highest ultra violet transmission the glass should be as thin as possible.

H. *Pale blue green,* G584J, 3 mm.

This glass is used in connection with purple glasses to remove the transmission of extreme red and cut the ultra violet as little as possible. It transmits as much ultra violet as the red purple ultra G586A.

I. *Blue Purple Ultra,* G585 M, 3 mm thick. This glass transmits between .40μ in the blue and .30μ in the ultra violet.

J. *Red purple ultra,* G586A, 4.2 mm, transmits between .42μ in the violet and .34μ in the ultra violet. Useful for spectacular effects due to fluorescence.

K. *Violet ultra,* G586AW, 8.6 mm., Fig. 29K.

A thicker and denser glass transmitting but a narrow band of ultra violet between .380μ and .344μ. This glass appears nearly opaque and an arc lamp observed through it appears a dim blue scarcely visible. The transmitted ultra violet causes many substances to fluoresce. While of greater purity the ultra violet transmission is so much less than the G586A that it is not often used.

General Remarks on Glasses for Stage Lighting

A choice of many colors is desirable for stage illumination. The principal colors available in glass are listed above. Slight variations in hue and density occur from piece to piece of the glass owing to variation from melt to melt and to the thickness of the individual pieces. The list of colors was incomplete until the theatre blue, a new type of blue glass, was developed at the Corning Glass Works. Aside from the ordinary colors whose use has been long known two trick colors are here described.

Ultra violet transmitting glass, G586A, enables the use of a strong beam of ultra violet with but a small amount of visible radiation. The result is a dim violet or purple light which does not illuminate objects to any extent. Under this light some substances fluoresce brightly and allow startling and spectacular appearances.

The *"Surprise"* glasses, *"Gray Surprise"* and *"Pink Surprise,"* while not greatly changing the colors of the background, have an enormous effect in enhancing the natural pink of the complexion and should greatly lessen the amount and simplify the process of "make-up."

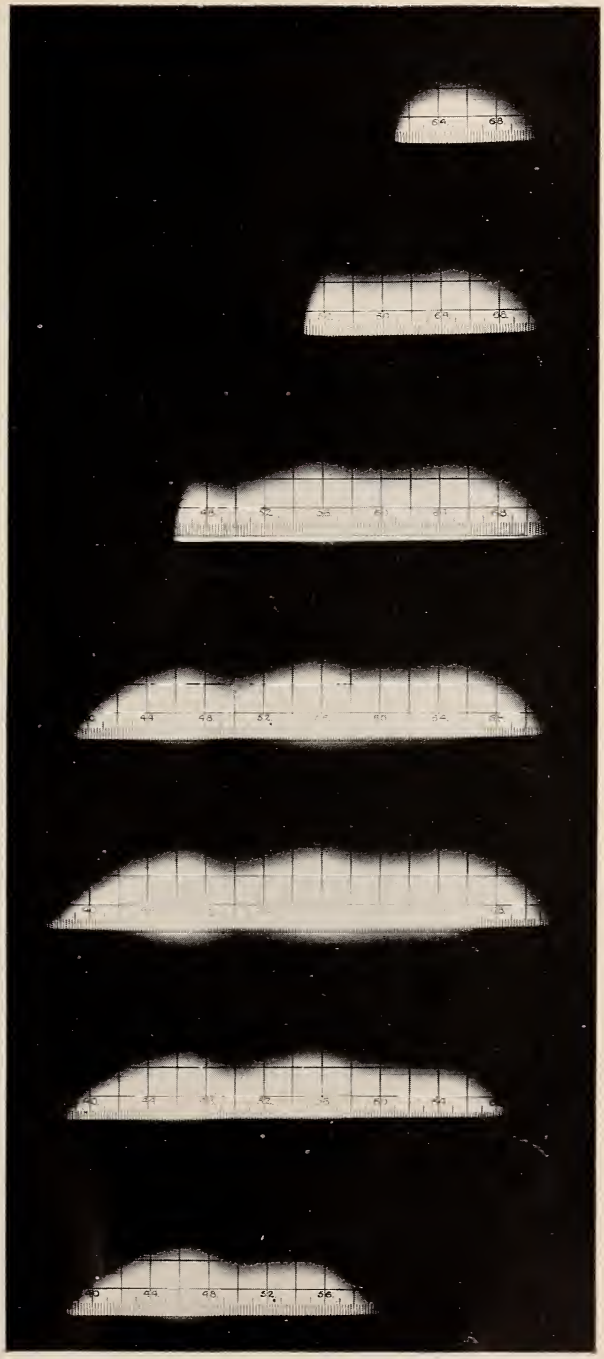


Fig. 1.
SeleniumRed.
G24

Fig. 2.
Selenium Orange
G34

Fig. 3.
NOVIOL C
G38H

Fig. 4.
NOVIOL O
G38L

Fig. 5.
Clear

Fig. 6.
Heat Absorbing
G124J or G392H

Fig. 7.
Blue-Green
G403ED G584J

Fig. 8.
Theater-Blue, light
G552PR

Fig. 9.
Theatre-Blue, dark
G552PY

Fig. 10
Signal Blue
G50

Fig. 11.
Dark Blue
G54

Fig. 12.
Violet
G53C

Fig. 13.
Blue Purple Ultra
G585M

Fig. 14.
Red Purple Ultra
G586A

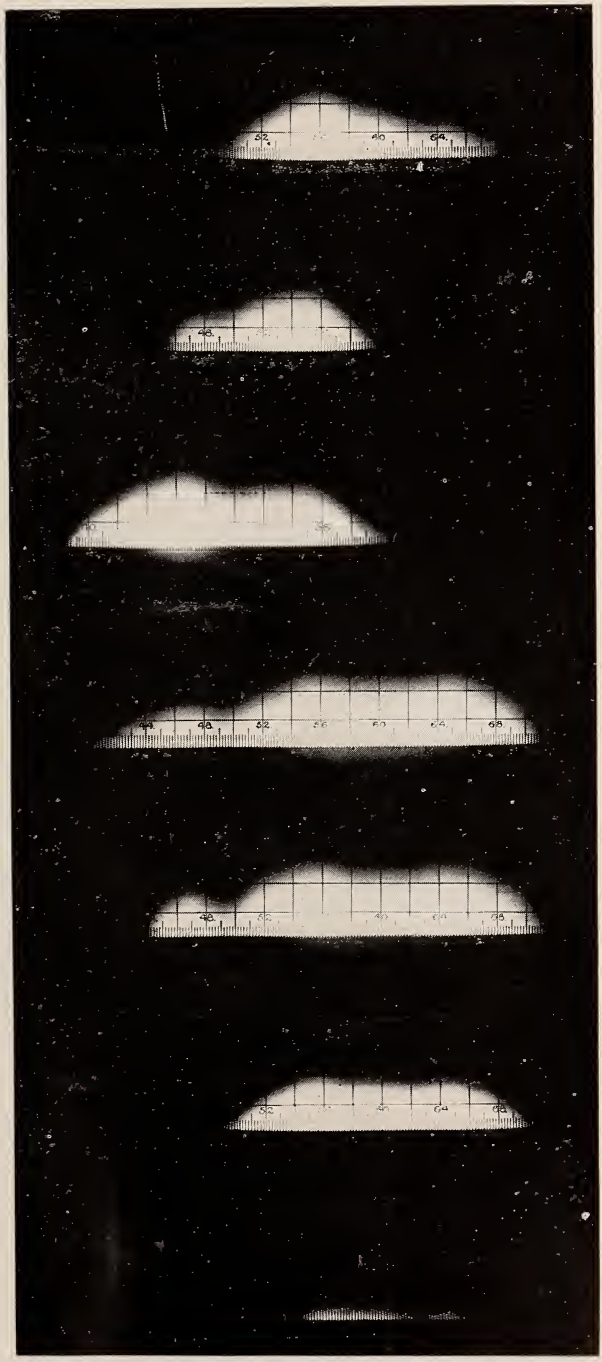


Fig. 15.
Greenish Yellow
G311AW

Fig. 16.
"Grass" Green
G401CZ

Fig. 17.
Signal Green
G40D

Fig. 18.
Pale Amber
G30B 1.5 mm

Fig. 19.
Canary
G371AR

Fig. 20.
NOVIWELD
shade 3

Fig. 21.
NOVIWELD
shade 6

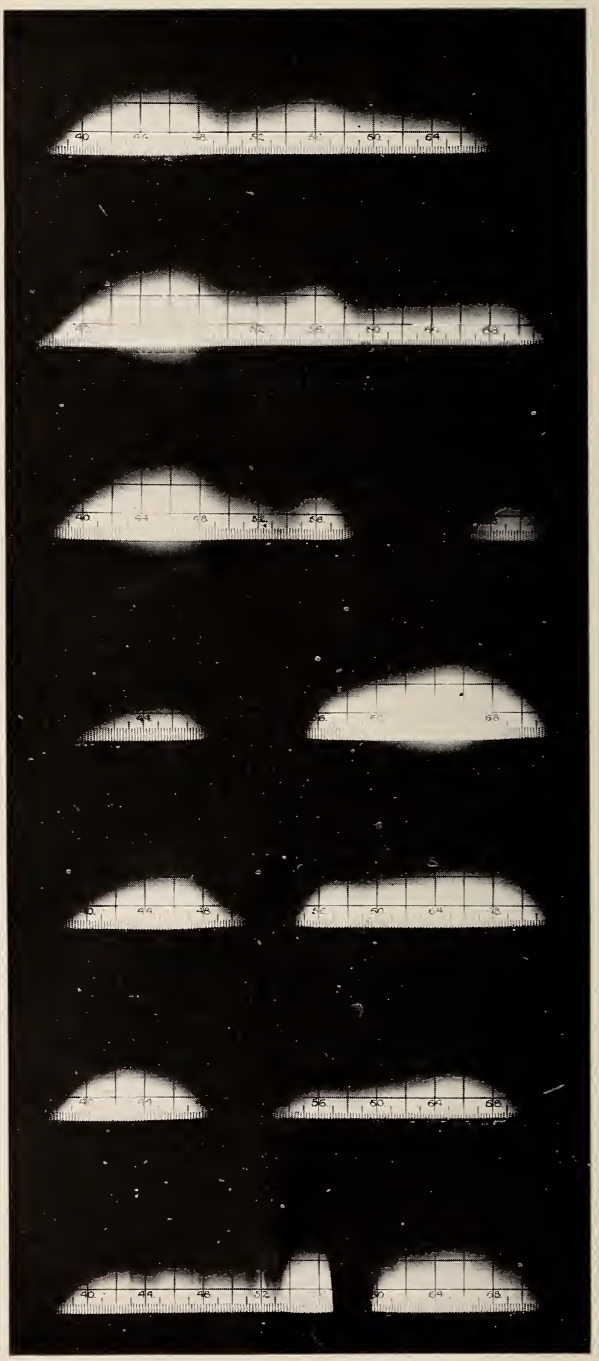


FIG. 22.
DAYLITE
G90A

FIG. 23.
LUNAR WHITE
G57

FIG. 24.
Light Blue Purple
G55

FIG. 25.
Gold Ruby

FIG. 26.
"Royal Purple"

FIG. 27.
Amethyst
G554CP

FIG. 28.
"Gray Surprise"
G555P

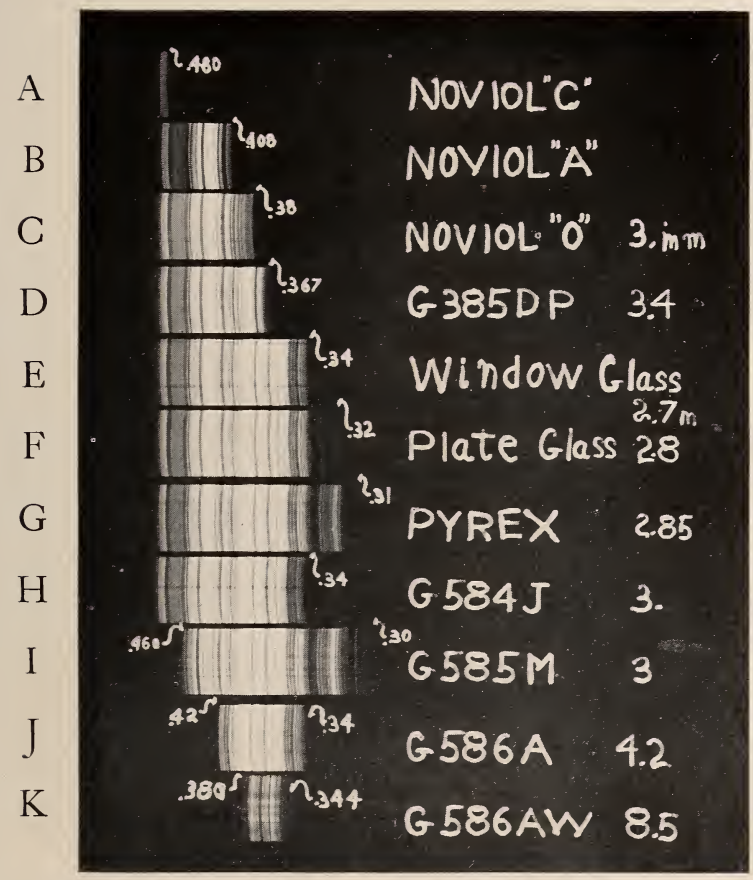


FIG. 29. Ultra Violet spectra of glasses. Taken with quartz spectrograph using iron arc as light source. Long wavelengths to left. The longest wavelengths shown are about .500μ in the blue-green and represent the limit of sensitiveness of the plate used. The figures indicate the wavelength of the last line transmitted by each glass.

DISCUSSION

Mr. Kelly: I would like to suggest to Dr. Gage that he demonstrate the use of the canary yellow glass for removing the excess violet from the light of the high intensity arc. Mr. Kunzmann I believe, is especially interested in this.

Dr. Gage: I have not used the yellow canary glass in this demonstration.

Mr. Kelly: Perhaps you can use something similar to illustrate the point.

Dr. Gage: I have here a piece of light amber glass which has about the same effect as the canary yellow glass. This glass removes somewhat more of the blue and violet than the yellow. Hence, it causes a greater decrease in the screen intensity.

Mr. Richardson: What percentage of light is absorbed with glass of the proper quality to obtain a pleasing warm color with the high intensity arc?

Dr. Gage: I think it would be possible to obtain the desired result by absorbing 20 or 25% of the light. Using the glass I have here (demonstrated) which is what we have in mind to recommend for this purpose, you will note that a greater proportion of the blue and violet is absorbed than is the case with the red and green. This glass you will note has just the opposite effect of the so-called daylight glass. I fear that the spectral cut off in this particular sample of glass is too sharp. The canary glass might be used or we have glasses which are practically colorless, and which will eliminate only the ultra-violet.

Mr. Griffin: Is that glass which you have just demonstrated easily obtainable?

Dr. Gage: All of the glasses I have shown you are easily obtainable in some form, although this form might not be the most desirable for some particular use. Ordinarily the glass we make is pressed out in the form of round or square pieces or in some form used by the railroads. It is not difficult to get glass in any shape for which we have molds.

Mr. Richardson: Would it be practicable when using these glasses on the light source side of the film to make them from a glass of the kind from which projection lenses could be made?

Dr. Gage: The simplest way would be to use it in the form of two inch or three inch diameter disc, plane parallel on both sides, in front of the objective.

Mr. Richardson: You are allowing then two or three possibilities for losses. Could projection lenses in one of their elements be made of this glass?

Dr. Gage: The method of substituting colored glass for colorless glass would make a saving of about 8%; but let us try the color effect in the easiest way first.

Mr. Richardson: May I ask Dr. Kellner if in his opinion it would be possible to make an acceptable projection lens from such glass.

Dr. Gage: We could make colored glass suitable for lens manufacture.

Dr. Kellner: I should be glad to answer Mr. Richardson's question in my paper on relay condensers. I do not think a special projection lens is at all necessary; in fact it is quite unnecessary.

Mr. Kunzmann: I should like to ask Dr. Gage if he has made photometric measurements where light filters were used to eliminate the ultra-violet rays? I should like to know what percentage of light is lost under such conditions.

Dr. Gage: No, I have not.

STEREOSCOPY AND ITS POSSIBILITIES IN PROJECTION

By Hermann Kellner

THE words stereoscopy and stereoscopic are derived from the Greek words Stereo and Skopein which means "solid" and "to see." A stereoscopic picture is a picture that represents a solid aspect of an object similar to the impression gained when the object is looked at with both eyes in the natural way.

Before speaking about our subject proper I should like to recall a few fundamental facts that have a bearing on the matter. When we fix a point of an object we direct our eye in such a way that the image of the point falls upon the most sensitive part of the retina which is called the fovea centralis which, as the name indicates, is a depression in the approximate middle of the retina. The diameter of this fovea is very small and covers therefore a very limited field, so that when we want to look over the detail of an extended object we have to direct our eye in such a way as to bring the images of the different parts of it successively on the fovea. An object whose image falls on the fovea is said to be seen with direct vision. Outside of the fovea in the indirect field, our ability to distinguish fine detail, the so-called visual acuity, is very much lower than in the fovea.

The sensation of depth must depend on our ability to distinguish differences in distance because the property of depth implies that different parts of the object are at different distances from the observer. When we look at an object with both eyes we converge the axes of our eyes in such a way that the image of the object falls on the fovea of each eye. When the two images fall on corresponding points of the foveae of the two eyes, they are seen as one image. If these images do not fall exactly upon the corresponding parts of the foveae, the images are not seen as one. The approximation with which the two images have to be superimposed upon corresponding parts of the fovea depends on the visual acuity of the eye which, in turn, depends upon the structure of the retina, much in the same way as the detail that can be photographed depends on the size of the grain of the emulsion. The ability to separate two images falling nearly together on the retina or on corresponding parts of the two retinae depends also on the skill of the observer and his familiarity with such observation. In general two images instead of one are seen when there is a difference of one-half minute between the angle between the optical axes of the eyes and the angle drawn from the object to the center of rotation to the eyes.

In figure 1 we assume E_L and E_R to be the left and right eyes of an observer which are directed upon the same point P of an object.

The optical axes of the eyes converge upon P under the angle α and by this angle the distance d of the object is estimated. If the distance between the pupils is small in comparison with the distance of the object we have $\alpha = 3438 \frac{e}{d}$ wherein α is expressed in minutes of arc.

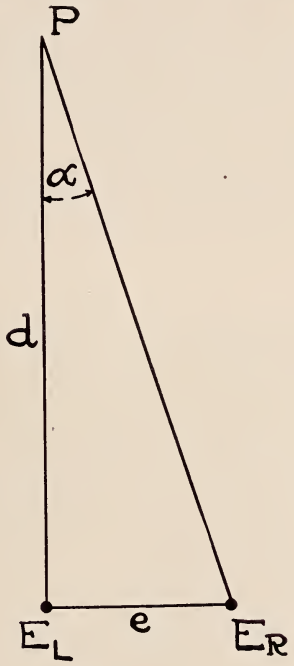


FIG: 1

As just mentioned such angular difference can be noticed by the appearance of a double image when the convergence of the eyes has to be shifted more than one-half minute. By introducing this value in the above equation and assuming an interpupillary distance of 65 mm we find that an object for which we have to converge the axes of the two eyes by one-half minute lies at a distance of about 440 meters. This represents the upper limit for stereoscopic perception of differences in distance to the unaided eyes. All objects lying more than 440 meters away will appear to lie in the same plane for the differences in the angles subtended by the eyes will be less than the limiting value of one-half minute. Upon our ability to judge changes in the angle α depends our ability to notice changes in distance. Together with a change of angle of convergence goes automatically

the adaptation of the focus of the eye to that distance. The eyes accommodate themselves automatically to the distance of the point of convergence. A simple diagram (Fig. 2) may illustrate these conditions. P_1 and P_2 are two rods located in a plane in front of the observer, P_3 is a third rod in front of the plane of P_1 and P_2. In looking at the left rod P_1 the eyes have to converge under the angle α_1 while in looking at the right rod P_2 they converge under the angle α_2. The angle of convergence when looking at the third rod P_3 is α_3. We get the impression of stereoscopy by fixing in succession the rods P_1, P_2 and P_3 and interpreting their relative distances by the change in the angle of convergence. When rod P_3 lies so nearly in the plane of the two other rods that the change of convergence is below 1/2′, all these posts will appear in one plane.

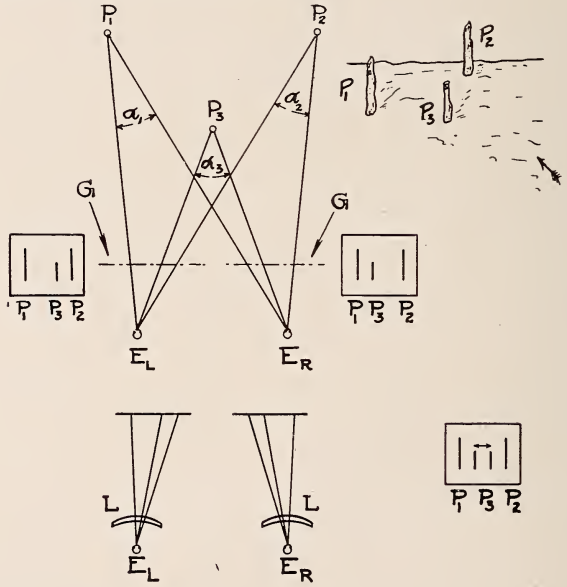


FIG. 2

We shall proceed now to construct a stereoscopic picture, a stereogram of this object. For this purpose we lay a plane through our diagram, Fig. 2, perpendicular to the plane of the paper and parallel to a plane through the center of rotation of the eyes. This plane, shown by the dotted lines *G G*, is intersected by the lines of direction from the centers of rotation of the eyes to the various points of the object and thus two miniature pictures of the object are projected on this plane, one as seen by the left eye and the other one as seen by the right eye. We see that in the left picture the center post appears to be shifted to the right, while in the right picture it is

Fig. 3

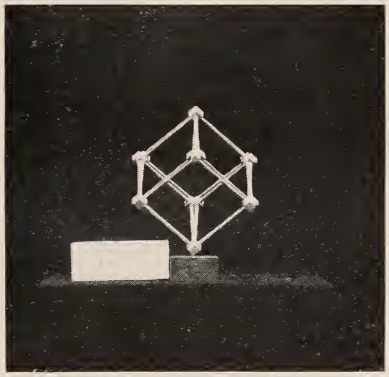


Fig. 4

Fig. 5

apparently moved to the left. If we now prepare two drawings, one for the left eye and one for the right, in which the representation of the relative positions of the posts is the same as in the projections on plane *G G*, an observer looking at these pictures from a distance equal to the distance between the plane of the eyes and plane *G G* will see an exact reproduction of the object in which the same impression of depth is obtainable as was observed when looking at the original object. Since the distance between the interposed planes and the eyes is much shorter than the distance between the object and the observer's eyes, we have to add a pair of suitable lenses of proper power and other optical qualities in front of the eyes to form an image of the object of the same distance as the object proper. Such a combination of a stereogram and a pair of lenses is called a Stereoscope. When we look through this instrument at the left and at the right reproductions of the object the direction of the axes of the eye and the angle of convergence between these axes will be the same as when we look at the object directly and, when we look at the three posts in succession we shall gain an impression of their distance from the observer and from each other. An important fact may be mentioned here. When we fix a post, for instance P_1, with both eyes this post will appear singly. Post P_3, next to it must evidently appear double unless it just happens to lie at such a distance from the eyes that its image falls on corresponding points of the two retinae outside of the foveae. This will take place when the angle α at the object, seen in the indirect field is equal to the angle at the left post. All points from which the centers of rotation of the eyes appear the same angular distance apart lie on a circle which goes through the center of rotation of the eyes. This circle is called the Horopter. All objects lying on this circle appear single when an object somewhere on it is fixed. Figures 3, 4, and 5, represent the appearance of a skeleton cube when the eyes are fixed for the front corner, a mean plane and the rear corner, respectively. It can be plainly seen how in the first case the sides of the cube diverge towards the rear, in the last case diverge toward the front, while in the second case they diverge forward and backwards from the point of fixing. It can also be seen from Fig. 4 that points lying approximately on the Horopter circle appear simultaneously sharp.

We can fuse a stereoscopic pair of pictures together into a solid picture when the pair is such that when looking at the different points in the picture the convergence of the eyes undergoes changes similar to those through which the eyes go when they look at the object. In examining an object the eyes feel themselves through its depth by varying their convergence successively for its different points and combining these impressions into a mental picture.

The ability to interpret lateral differences of location of images in terms of distance from the eye is not born into us but a matter of training. A child will try to grab the moon just in the same way as it reaches for its bottle. In time it begins to realize that it can get hold

of the bottle and connects the greater angle of convergence between the optical axes of its eyes with the proximity of the welcome object and by the same reasoning becomes aware that objects which are seen under a small angle of convergence like the moon, are beyond its reach. The ability to judge distances is simply a matter of experience, memory, and development of judgment. It is really remarkable how well trained we become in the use of the simple range finder with which nature has provided us in form of our two eyes and which does not even have a scale to read the ranges on.

Stereoscopic seeing can evidently be accomplished only when both eyes are functioning and when the left eye sees the left picture and the right eye sees the right picture.

An important point should be mentioned here which has a bearing on the correct appearance of stereoscopic pictures as well as photos in general. It is what is often called distortion but should be termed as lack of correct or true perspective. We all know that when we take a picture of a person lying on the floor with his feet towards us, the feet appear immense and the head unbelievably far away. When

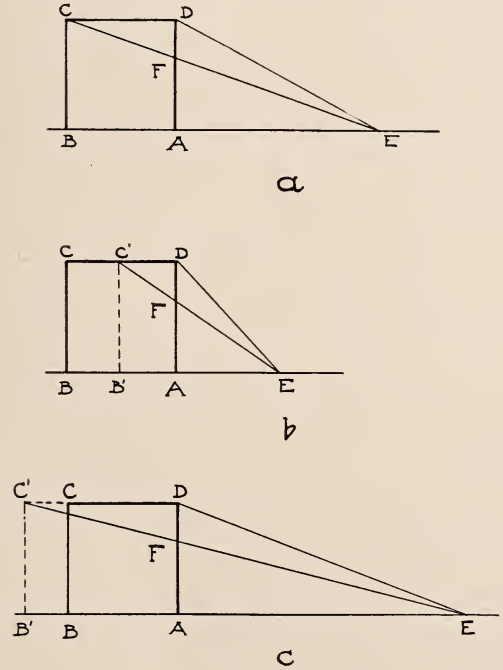


FIG. 6

we view such a picture, if necessary with the aid of a lens, from a distance about equal to the back focus of the lens the picture, although, of course, its composition will not be improved, will look at least correct. The explanation is rather simple.

If we assume, in figure 6a, $A\ B\ C\ D$ to be the section through a cube that has been photographed from a point E and $A\ B$ to be the plane of the photographic plate. The line $E\ C$, drawn from the center of projection E to the rear upper edge of the cube will intersect $A\ B$ at F. If the picture is observed from a nearer point, as shown in figure 6b, the prolongation of $E\ F$ over F will intersect the cube at C' and we shall gain the impression that the depth of the cube has been reduced by the distance $D\ D_1$. In the same way a picture of the cube when observed from a greater than the correct distance appears stretched in depth. See figure 6c. Only when the stereogram is observed through lenses of the same E.F. as the lens with which the pictures were taken and from the same projection center the image will be true.

Can an image appear stereoscopic when viewed with one eye? It will under certain conditions, when seen from the correct view point appear more solid than when those conditions are not held. Light and shade as well as color will assist perspective immensely in the suggestion of depth and distance, but a means for judging the distance as we have it in binocular observation is missing at least in a still picture.

There is, however, a way of estimating distances with one eye which is of importance in motion picture projection. If we go back to Fig. 2, and assume a monocular (one-eye) observer placing his eye in succession in the positions of the right and left eye of the binocular observer, he will first see a picture like the one seen by the left eye of the binocular observer. When the observer moves toward E_R the center post moves from its apparent position near the left rod towards the right post and it is by the amount of this shift in combination with displacement of the eye that he is able to form an opinion whether the center post lies in front of or behind the others and how far. The side shift of the center post is called parallax and similar apparent motions of cross wires and other reference marks, etc., are used very frequently in the adjustment of measuring instruments. It is important to note though, that to see differences in depth it is essential that the observer's eye is kept moving. The amount of shift is obviously inversely proportionate to the distance of the objects from the observer and proportionate to the distance between the objects and the amount of lateral motion and by the relative amounts of these shifts it is possible to estimate distance and depth.

Stereoscopy is possible only if the right and left eyes are used for observing the object and by changing their convergence as a measure of depth, or with monocular observations, when the eye is moved and from the relative shift of the parts of the observed object an impression of depth is given.

We can see pictures stereoscopically only when to the right and left eye in binocular observation a pair of co-ordinate stereograms is offered in a suitable way or when with monocular or binocular observation a sequence of pictures taken by a moving camera is presented in rapid succession like motion pictures taken from a moving car, railroad train, etc.

We shall now discuss means for viewing stereo pairs. This can, in so far as my knowledge goes, be done in the following way only:

I. By simultaneous viewing with both eyes taking care that the right eye see only the right picture and the left eye the left picture. The following possibilities are known to me:

(a) Each eye looks through a lens, prism or mirror or, if sufficiently trained, without such optical assistance at its picture. It is always possible to fuse stereo pairs in this way when the distance between corresponding points in the two pictures is not greater than the distance between the pupils of the eyes. The optical means just mentioned serve to allow observation of pictures the corresponding points of which are further separated than the interpupillary distance. When such points are further separated than the interpupillary distance the axes of vision of the eyes without optical aid would have to diverge for the purpose of fusing the images which is impossible. The whole arrangement is the well-known Stereoscope in the form given it by Wheatstone, Brewster, Helmholtz, and others.

(b) The pictures are printed in different colors, for instance, the right picture in red and the left picture in blue. The right eye looks through a color filter that passes only the red and absorbs the blue light while the left eye uses a blue filter which does not pass any red light. The right eye sees the right half picture in red, while the left eye sees the left half picture in blue. When both halves are fused together a stereoscopic picture appears in a mixed color. It appears approximately white when the colors are complementary. It is, of course, not necessary to use just red and blue. Comparatively large parts of the spectrum may be contained in the colors of the halves as long as the filters prevent the eyes from receiving the wrong picture.

Corresponding points in the pictures must not be further than the interpupillary distance apart for the same reason as given under (a).

Since our eyes are not chromatically corrected and the blue images are formed at a shorter distance from cornea and lens than the red images a change in accommodation is required when we look from a red object to a blue object. Since in this case one eye looks at the red and the other eye at a blue object, both eyes work under strain because each eye requires an accommodation different from the other to see a sharp image. This can be overcome by the use of correction lenses.

This method dates back to W. Rollmann who described it some 70 years ago.

(c) The half pictures are interwoven into one which is composed of a great number of narrow vertical strips of equal width. All the odd numbers of strips contain one picture, for instance, the right one, while the even numbers contain the left picture. A line screen is mounted with its lines parallel to the strips a short distance in front of this combination picture in such a way that, when an observer looks at the picture from a certain distance the lines of the screen obscure the strips of the left picture to the right eye and the strips of the right picture to the left eye. These ingenious stereo pictures were first made by Mr. H. E. Ives.

(d) Some other suggestions for viewing stereoscopic pairs for instance, by the use of polarized light may be left out of consideration here because they are too far remote from practical feasibility.

II. No apparatus for viewing stero pictures with one eye by a parallax method is known to me. It would produce the same effect as the projection apparatus for the same purpose which will be described further down.

Some of the possibilities of stereo projection of a still picture so that it may be observed by a number of people are analogous to the possibilities for viewing stereo pairs by a single observer. We may mention the following:

I. Continuous projection, and simultaneous viewing of the halves by both eyes.

(a) The halves are thrown side by side on the screen and viewed by each observer through a sort of prismatic spectacles which may be combined with an opera glass for the purpose of obtaining magnification. The whole room forms a stereoscope in which there is a pair of half pictures common to all observers and each observer wears a special appliance to aid him in the fusion of these images. The practical difficulties of this scheme seems unsurmountable although it is revived very frequently by inventors. The principal difficulty lies in the fact that the two pictures on the screen lie necessarily a considerable distance apart and very strong prisms are required in the spectacles for the fusion. Further, the same pair of prisms can only be used by observers who are placed in a narrow circular zone at a certain distance from the screen. Observers at other distances need different prisms. If a magnifying arrangement were to be combined with such spectacles an adjustment would be necessary for adapting the apparatus to the interpupillary distance of the different observers. The inconvenience of spectacles for the purpose is obvious.

(b) The half pictures are superimposed upon the screen in different colors much in the same way as mentioned above and are viewed through colored spectacles. This method is used fairly successfully in lecture rooms. Its drawback lies in the fact that each observer has to be supplied with colored glasses. They do not require special adjustment like those mentioned under (a) and for coarser work gelatine filters mounted in cardboard are sufficient. If there is much fine detail to be observed the strain on the accommodation will

be noticeable. This can be avoided with a concave surface on the blue and a convex surface on the red filter for compensating the difference in accommodation.

J. C. D'Almeida described this method of projecting and viewing stereoscopic pictures in 1858.

II. Discontinuous projection. The right and left pictures are superimposed and shown in rapid succession. They are viewed alternately with the right and left eyes through a shutter which alternately exposes the right picture to the right eye and the left picture to the left eye. The practical difficulty which is not unsurmountable is that every person has to be provided with a shutter that changes in synchronism with the shutter exposing the pictures.

III. One proposal has been made and patented a number of times which has probably never been critically tested by its sponsors, otherwise the patent office would not be flooded with worthless records. I mean the superposition of two half pictures on the screen and the viewing of them without any further assistance with one or both eyes. After the foregoing it seems quite obvious that our eyes cannot use the different points of the two superimposed different images together any more than it can see stereoscopically two superimposed printed pictures. The addition of a shutter which presents the halves alternately does not change matters in any way as long as both eyes receive each picture simultaneously.

A German ophthalmologist and physiologist, Dr. F. Krusius has shown, however, that under certain conditions with slow alternation of the superimposed pictures there is a true stereoscopic effect. Unfortunately, though, the objects do not stand still but seem to move in space with reference to each other about those points in the picture which do not appear double, somewhat in the same way as we

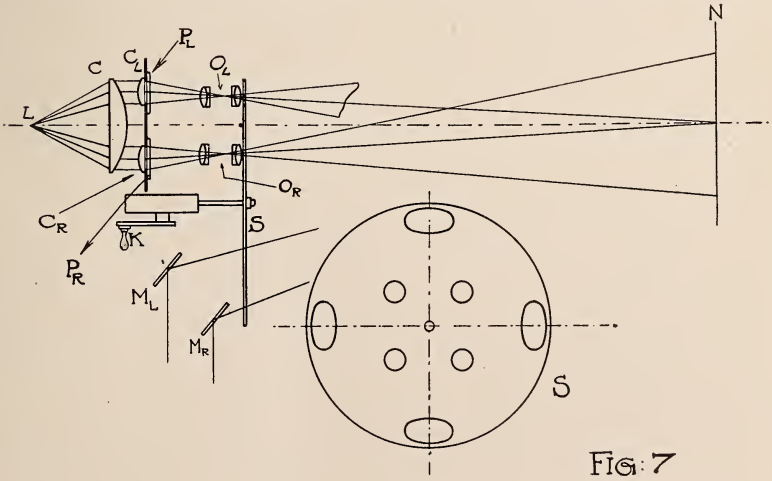


FIG. 7

notice differences in distance of objects by their parallax when we change our point of view. The subject seems to be interesting enough to discuss here although I am not certain whether I am entirely in agreement with Dr. Krusius. His article is written in very involved and technical language and hard to understand for the non-physiologist. The apparatus for demonstrating the effect is also different from his.

We have here (figure 7) a kind of duplex projection apparatus with a light source L, a large condenser C, in front of which is mounted in a frame a pair of smaller condensers C_L and C_R which focus the light source in the projection objectives O_L and O_R. In front of these small condensers is places a pair of stereo pictures P_R and P_L which are projected and superimposed on the screen N. In front of the objectives O_R and O_L can be rotated, by means of a crank mechanism K, the circular shutter S into which are cut two concentric series of apertures in such a way that when the shutter is rotated a right and left picture are alternately projected on the screen N. The apertures of the holes are so proportioned that the right and left pictures appear under the same brightness on the screen. When we place the stereoscopic halves of a simple object like the co-ordinate cross of figure 8 on the object holder and turn the crank we notice that at a speed of the shutter fast enough to produce over 16 alternations for each half the right and left halves of the pair are simply superimposed on the screen. The corresponding points are in register, while all other points appear double. The background is free from flicker. As soon as the shutter speed is reduced to about 10 changes and less, the time between the appearances of the right and left pictures becomes so great that persistence of vision no more keeps the pictures in continuous appearance and we see the horizontal arms of the cross swinging back and forth between the end positions. While this swinging takes place the picture on the screen appears with perfect stereoscopy. With further reduction of speed the swinging motion becomes jerky and the picture ceases to look solid. The next three slides (one only is reproduced in Fig. 9 because they look very much alike) show pictures of the skeleton cube used before. In the first one the front corners of the half pictures coincide on the screen in the second one the upper corner, while in the third one the rear corners are brought together. With high shutter speed the projected images are identical with the figures 3, 4, 5. When the speed is reduced the cube appears solid and the points which were doubled with the high shutter speed oscillate about those which are in coincidence. The young lady in figure 10 will plainly shake her finger at the observer.

The experiment depends only on the speed of the shutter and not on the form, sequence and number of holes. This is contrary to a statement which was made recently in the English literature where the solution of the problem of stereo motion pictures on this principle was announced. We can obtain a stereoscopic effect this way, but not without flicker and not without the moving of the

Fig. 8

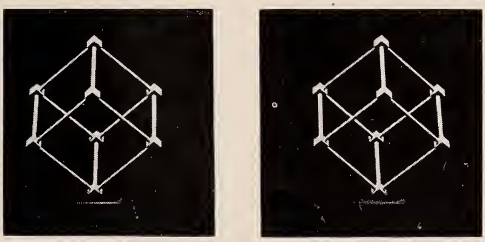


Fig. 9

Fig. 10

different parts of the object relatively to each other in the same way as we see it when we observe an object and change our view point.

If we place our eyes behind the shutter and observe the screen by looking with one eye through the inner circle of holes and with the other eye through the outer circle of holes we obtain a true stereoscopic picture, quite independent of shutter speed because then each eye sees only the picture which it is supposed to see. The observation is facilitated by the mirrors M_L and M_R which are attached to the apparatus in the manner shown in the figure.

Motion pictures can be projected stereoscopically by using methods similar to those used in the projection of still pictures. Successful attempts have been made with synchronized shutters in front of the observers eyes and with less perfection by using J. C. D'Almeida's principle.

For those who have a further interest in the subject I mention here as good examples of correct application of the shutter principle the U. S. patents 1,276838, 1,284673, 1,349018, 1,396651. I may mention here the U. S. patents 1,307074, 1,383538, 1,472608, and 1,477541, as some which will not stand the critical test because they fail to realize the necessary conditions of correlating the proper pictures with the observers eyes. Some of them are rather amusing in the complicated reasoning with which the inventors try to dodge a simple principle.

Scientific Bureau.
Bausch & Lomb Optical Company,
Rochester, N. Y.
July 17, 1924.

DISCUSSION

Mr. McNabb: I should like to ask Dr. Kellner if his paper has touched upon any phases of the Spoor process.

Dr. Kellner: I do not know enough about the process mentioned to express an opinion.

Mr. Powrie: A picture was recently shown me by Mr. Spoor produced by his process. It was an image of about twice the width of the motion picture positive. He explained that two images were superimposed in the one picture, but I couldn't see that the picture was stereoscopic, viewing it with two eyes in the normal position; it was not projected on the screen. I can't see any difference this would make, but I understood some time ago that it was a process depending on the stereoscopic parallex, but evidently it carries two images on one film and how the image is differentiated for each eye I don't know.

Mr. Richardson: I have heard a great deal of talk about the Spoor proposition, and I have understood from many that it is impractical. I noticed, recently an illustration of one point in the doctor's argument. I was looking at a colored magazine cover—red and blue. The red seemed to stand out far ahead of the blue; I had never noticed it before and was rather startled. I didn't know whether something had gone wrong with my eyes. I see now what the explanation of it really is.

One question, I should like to ask: I was at the Rialto Theatre recently, talking to Dr. Reisenfield. He had some film projected which was composed of a red and green picture. One figure lying down seemed to come out so that you seemed almost able to touch the feet. I should like to ask the doctor what really causes such an effect: Another thing, I have often tried closing one eye and find I get much the same impression of distance and steroscopic effect as with both eyes.

Dr. Kellner: An exhaustive answer to Mr. Richardson's questions would mean practically a repetition of this paper. To save time I shall be very glad to explain the doubtful points to Mr. Richardson privately.

Mr. Griffin: I should like to ask Dr. Kellner if he saw the Teleview pictures and what he thinks of them.

Dr. Kellner: I have not seen the Teleview pictures but have an attachment on this demonstration lantern which will show the principle. (Demonstration.) These two mirrors, one for the left and one for the right eye allow you to look at the screen through the same shutter openings through which the projection takes place, in

such a way that each eye sees always and only the picture which it is supposed to see. From what I hear, Teleview pictures must be very fascinating, but the audience must look through port-holes with rotating shutters which is a great inconvenience from the practical standpoint.

Mr. Potter: It seems to me that this paper illustrates very well the fundamental function of the Society of Motion Picture Engineers. Dr. Kellner has taken a question on which there is much misunderstanding, analyzed it, and brought together considerable data on the subject. It will appear in the Transactions, and be available to those in the industry who might, without such information, waste a good deal of money on stock selling schemes and in other ways. With the fundamental principles available, a little study will indicate whether or not the principles are sound or otherwise. I think this is one way our organization can be of benefit to the industry.

Mr. Richardson: That is true of the individual as well. The paper has enlightened me with relation to a thing which has puzzled me for years. It has a good deal to do with many things—vision, theaters, and projection. Your eye automatically focuses on one point and we have a relatively wide field of vision but really only see one point clearly. I understand now why that is true. It is through such discussion that many things which have been puzzling us are made clear.

EFFECT OF HUMIDITY UPON PHOTOGRAPHIC SPEED

By F. F. Renwick

WHILE it has been known for many years that the sensitiveness of photographic materials falls when the gelatin is allowed to absorb moisture by exposure to humid air and for a few special purposes, such as in astronomical work, precautions have been taken to avoid this effect, it is probably not too widely known among users of cine films that the effect is large enough to be of practical importance under adverse conditions. It was, therefore, thought worth while to present to you some quantitative data obtained in the Redpath Laboratory of E. I. duPont deNemours & Co. showing the magnitude of the effect observed with a variety of materials, more especially since our observations show that the phenomenon is a very complex one. In all cases, the results given are the averages of a number of careful independent determinations and it should be stated that equilibrium was not considered to have been attained until the films had been exposed to the various atmospheres for at least 24 hours.

The following table summarizes the data obtained for eleven different materials, the normal speed of each being taken as 100 at 40% humidity. It will be seen that while two or perhaps three of the positive films appear to be almost unaffected by variations of moisture content within the limits of zero to 80% relative humidity, the remainder all show a decided drop in sensitiveness when they are allowed to come to equilibrium in an 80% saturated atmosphere, the loss of speed amounting in some cases to nearly 25%. On the other hand, seven out of the eleven materials examined showed a definite increase of speed on attaining equilibrium with a 20% saturated atmosphere, the increase ranging in amount from 6% to 18%, and in the majority of cases, sensitiveness is at a maximum at this degree of humidity.

When the films were completely desiccated, six of the eleven tested had practically the same sensitiveness as at 40% humidity, six are less sensitive than they were at 20% humidity, and only two are more sensitive than under any other conditions. While, therefore, it is clear that the majority of films are most sensitive after being desiccated in an atmosphere of 20% relative humidity, there seems no possibility of offering an explanation for it, or even of tracing any consistent relationship, since both the direction and amount of the changes occurring evidently depend greatly on the method of manufacture of the material employed.

In view of the highly specific character of these results, it is not improbable that the same makers' materials may at one time behave in one fashion, and at another time differently, and the figures here given are not intended in any way to classify materials of different origins, but simply to show that these different types of emulsion do exist, and that, therefore, no general rule is possible. Bearing in mind the risks on the one hand of producing static markings at very low humidities and on the other the loss of sensitiveness which almost always occurs under moist atmospheric conditions, there can be no doubt that it is desirable wherever possible to bring photographic materials to a state of reasonable dryness before use.

EFFECT OF HUMIDITY UPON PHOTOGRAPHIC SPEED

Cine Positives	*Tests at Each Humidity*	*Humidity* 0%	20%	40%	80%
		Relative H & D Speed			
Eastman	8	97	106	100	74
Du Pont	8	97	107	100	102
Agfa	4	98	98	100	102
Pathe	4	98	98	100	98
Ansco	4	105	110	100	93
Bay State	4	120	110	100	93
Powers	4	107	118	100	91
Average (36 tests)		102	107	100	92
Cine Negatives					
Eastman Superspeed	8	100	110	100	98
Eastman Par Speed	4	98	98	100	95
Pathe	4	69	102	100	78
Ansco	4	145	118	100	79
Average (20 tests)		102	108	100	88

(Average deviation of single tests 5%)

DISCUSSION

Mr. Powrie: I should like to ask Mr. Renwick whether it might not be possible that residual traces of material not washed from the emulsion might have subsequent action.

Mr. Renwick: I think this is highly probable, but I should include this under the term "Methods of Manufacture" referred to in the paper.

Mr. McNabb: I should like to ask if the tests were made on nitrate base.

Mr. Renwick: They were all made on nitrate base.

Mr. Briefer: On this interesting subject which Mr. Renwick develops, there are many factors involved which are worth while studying. For one thing, I think the thickness of the gelatin coating is an important consideration. The greater capacity of a heavy coating to absorb moisture would make a difference in the results with respect to the influence of humidity on sensitiveness.

Before digesting emulsions, it is customary to pour a preliminary plate. Under normal conditions, these test plates are exposed and readings taken, after drying. But, in the course of our work, there were occasions when time pressed and we exposed the test plates just after chilling, that is, while still wet. Under these circumstances, we could notice no real difference, photometrically between the plates exposed, before and after drying. On re-wetting a dry plate before exposure there is, as Mr. Renwick states, a real loss in sensitiveness.

Mr. Renwick: I think perhaps I can't answer Mr. Briefer entirely successfully without explaining that the methods employed for the accurate determination of sensitiveness are better than taking a film and exposing it in a camera with a standard comparison plate and looking at the resulting pictures. In modern laboratories that method, used in the early days of photography, has had to be abandoned for something more scientific. The whole of the data presented to you to-day was carefully prepared. I have not gone into the methods of testing we employed because it did not seem suitable for this Society's Transactions, but it involved the Hurter and Driffield system, logarithms, etc., and I can assure Mr. Briefer that I do not know of any other method of testing that can give you results accurate to within 2% or 3%, and I think I can guarantee the data presented to you to be accurate to that amount. There was no delay in exposing; it was done within 5 or 10 seconds after removing the film from the desiccator, the exposure being made by means of the standard H & D sector wheel devised by Hurter and Driffield.

Mr. Briefer: I do not wish to be misunderstood, I realize that the values given are the results of Hurter & Driffield exposures and photometric readings. I do not think any one can distinguish with the unaided eye differences in sensitiveness as slight as those shown by some of the figures. My intention was to inquire if consideration was given to the atmospheric conditions prevailing during the tests. There are times when it is important to determine this condition, especially with most sensitive emulsions; as otherwise, the results may be very misleading. Nevertheless, a paper of this type is of much value and invites one to look deeper into a very important subject. The vital question is not how much does humidity affect the speed of emulsions, but, what are the fundamentals involved. The value of this paper is more far reaching than appears on the surface. I think it opens a fruitful field for further research.

Mr. Crabtree: I think that considering the nature of photographic materials it is somewhat surprising that the results did not vary more than Mr. Renwick's figures indicate. In practice, a difference in speed of 10% is really not very serious, so that I think it is a tribute to the different emulsion makers that their photographic emulsions should be so constant in their properties. It would be interesting to have results on acetate base. The differences would probably not be so great as with nitrate base.

Mr. Renwick: Perhaps Mr. Crabtree may be under a misapprehension. This paper is not concerned with the uniformity of different manufacturers' materials. One batch only of each maker's goods is considered. It therefore does not deal with whether manufacturers are doing good or bad work.

Mr. Crabtree: I understand, but the variation is not so great as one would expect.

Mr. Renwick: There are some which to me seem very striking as the table of data shows.

THE STRAIGHT LINE DEVELOPING MACHINE

By R. C. Hubbard

IN MY PAPER at the Ottawa convention I treated a friction feed developing machine in which the film was fed spirally through the various units. A casual observation of the field has led me to believe that by far the largest percentage of machines in use today are what I term straight line machines. I have coined this name because in these machines the film is fed along a series of loops in the same perpendicular plane. (Fig. No. 1 illustrates a straight line

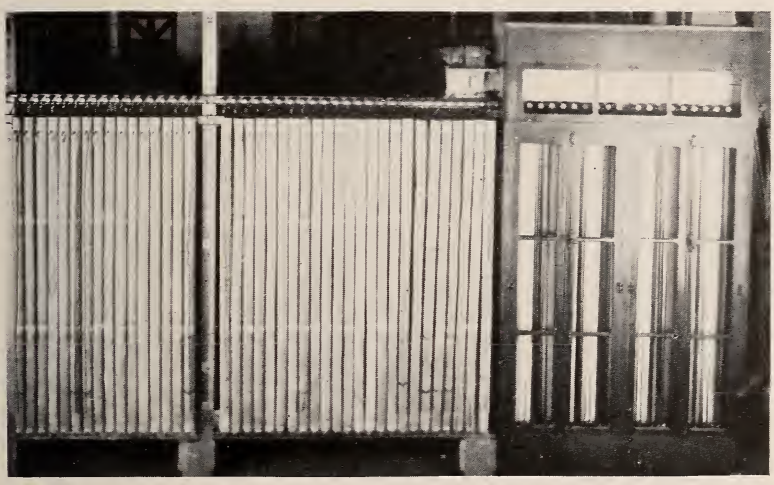


Fig. 1

tube machine. Fig.No. 2 illustrates a straight line tank machine.)

The general practice (See Fig. No. 3) is to have a toothed and flanged sprocket "A" driven, an idler Roller "B" and a weighted idler "C". The loops thus formed may drop down for any length desired into solution contained in tubes or thin perpendicular tanks. The depth of these tubes or tanks varies from six to ten feet in machines of different manufacture. I should say from a practical point of view that loops of from six to seven feet would be the best practice. This depends somewhat on height of room available. To be used satisfactorily the room should be at least 12 ft. in height in the clear.

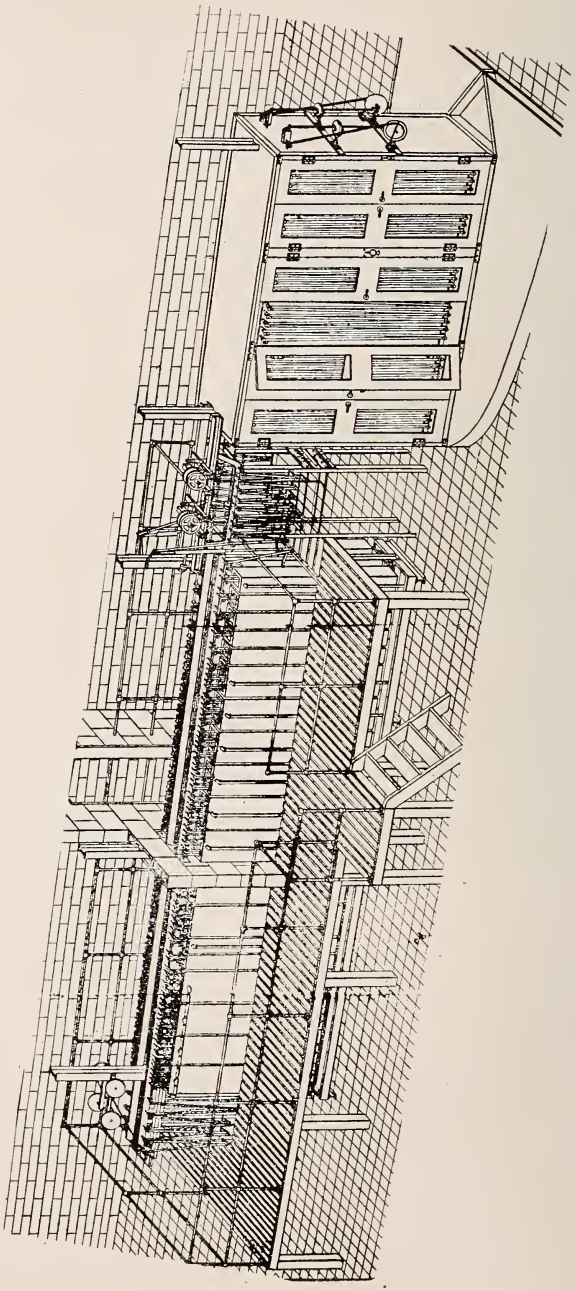


Fig. No. 2.

The machines are generally made double (see Fig. No. 4). This is quite an advantage in economy of space (see Fig. No. 5). At the start there should be two spindles for holding reels and some sort of elevator to carry enough film to supply the machine while a cement splice is being made. (See Fig. No. 6.) As there are about 40 ft. of film on this elevator, that would give a minute or more to make splice. In some of the slower machines an elevator is not provided, in which case the operator must pull film down in a barrel or other receptacle. This practice should be condemned as finger prints and abrasion will result.

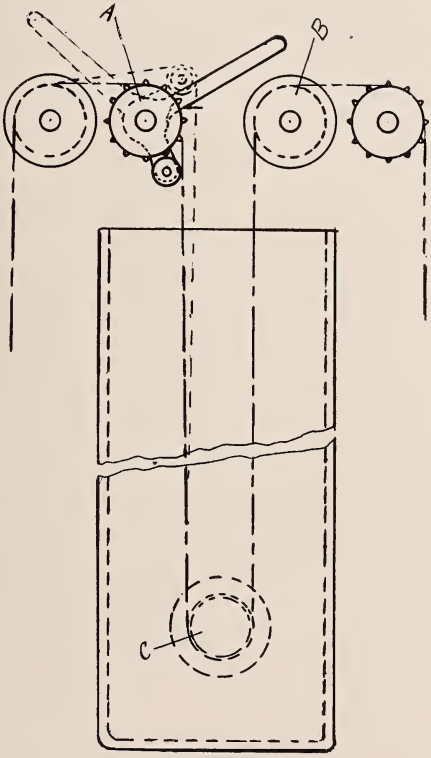


Fig. No. 3.

As in all machines having sprockets it is necessary to have film spliced so that sprocket holes are in line and due to the film being immersed for thirty minutes or more it has been found good practice to make splices 1/2″ to 3/4″ long.

The film first passes into the developing tubes or tanks. The number of loops for developer varies from 6 to 12 in different machines. Of course, everything else being proportional, right here is where the speed of machine is determined. With a machine of six

developing loops, a speed of 18 to 20 ft. per minute would be the maximum, and with a machine of 12 developing loops a speed of 35 to 40 ft. per minute could be used. To take care of the variations in emulsion speeds, printing speeds and strength of developer the length of loops is varied as well as the number of loops. To lengthen

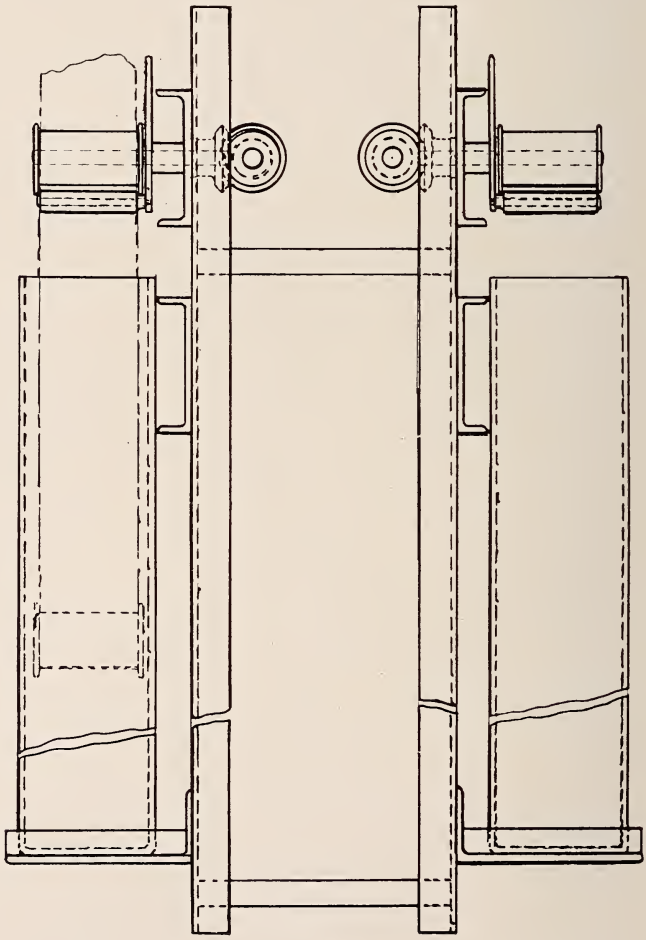


Fig. No. 4.

the loop and increase development you must in some manner stop the remainder of the machine by means of disengaging clutches. When it is satisfactory to steal film from some other loop this may be done by a device which will raise film by sprocket teeth for a short period (see Fig. No. 3). When it is necessary to raise loops so as to give less

development you must stop beginning of machine. If any radical change is made a more or less sharp line of demarkation will be the result. This can be reduced by means of allowing all mechanism to operate at all times, and providing means for operating a portion of it at a slower or a faster speed or normal speed.

In order to determine the proper development a ruby examining light should be placed between developer and rinse. This may be in form of light box (see Fig. No. 7) raised above tubes or tanks with ground and ruby glass on both ends so operator may observe film from either direction.

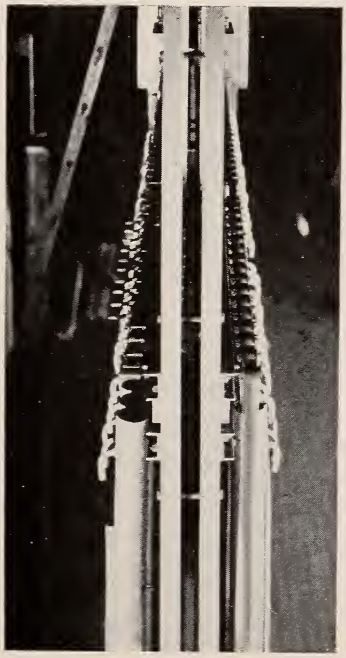


Fig. No. 5

The film next passes through a running water rinse tube and to the hypo tubes on tanks. There should be 50% more film in hypo than the maximum in developer, viz., if you have six loops in developer there should be nine loops in hypo and if you have twelve loops in developer there should be eighteen loops in hypo. After leaving hypo film will pass through an opening in dark room wall and in front of another examining light, which will be a diffused white light to the washing loops. Here should be provided two or three times as many loops as maximum in developer, viz., if six loops are in developer you should have twelve to eighteen in wash and if you have twelve

in developer you should have twenty-four to thirty-six loops in wash. In washing film in this manner, viz., passing it through slowly running water, sufficient time must be given for the water to dilute the chemicals in the emulsion until the trace remaining will not be sufficient to cause chemical reaction during or after drying. A thorough wash will always aid in faster drying. Film may be washed much more quickly by means of spray wash, but this type of machine does not lend itself readily to application of spray, so I should say it would be desirable to have the amount of film in wash three times the maximum in developer. An aid to thorough washing is to have as many changes

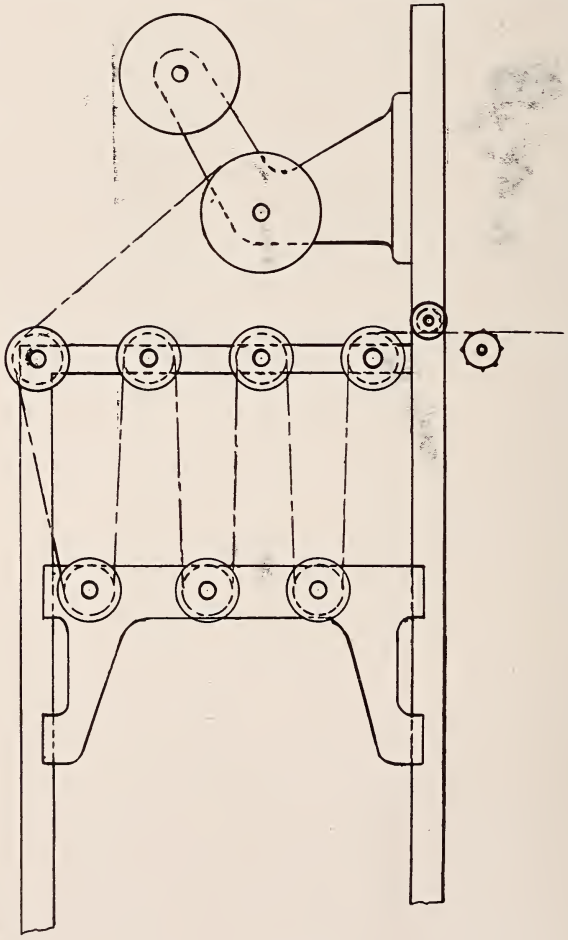


Fig. No. 6.

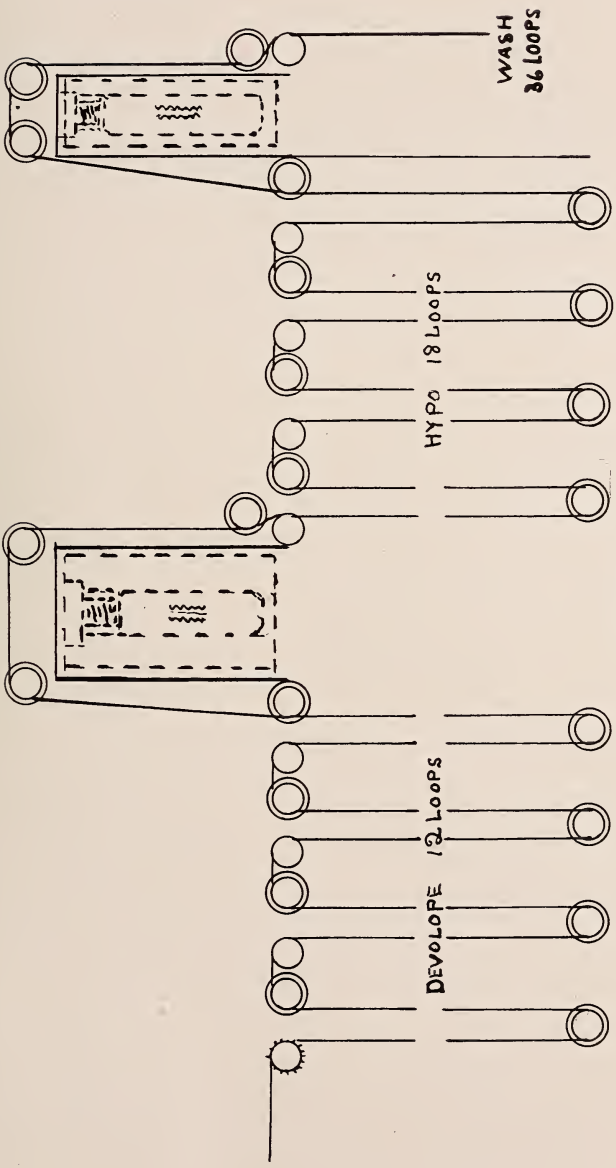


Fig. No. 7.

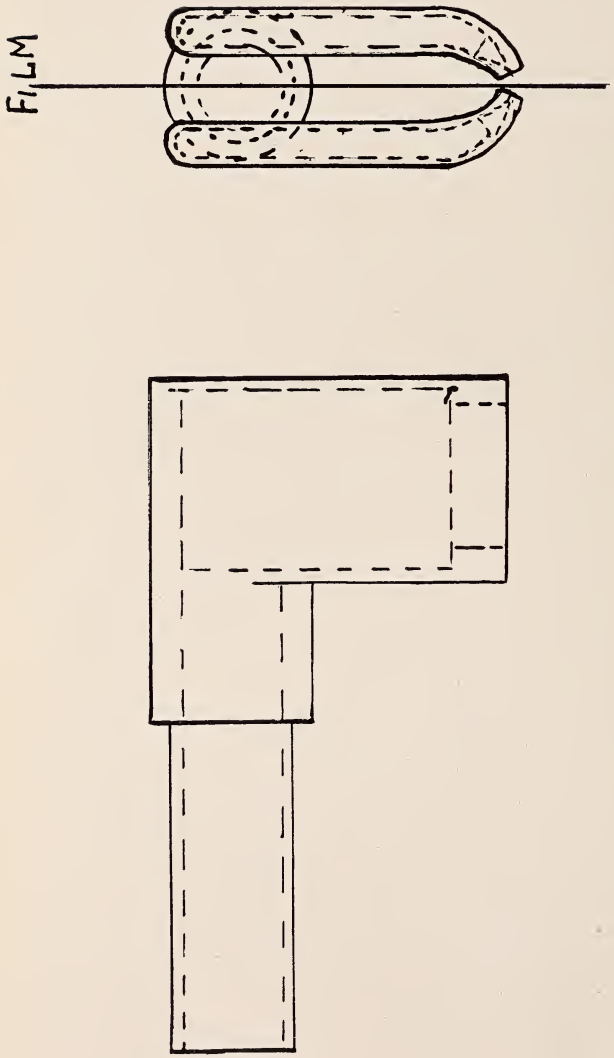


FIG. No. 8. Compressed Air Squeegee

of water as possible. That is, if tanks are used they should be divided into at least six sections. Each section should have separate supply and discharge pipes. If tubes are used an even greater number of changes may be arranged.

If it is desirable to tint film tubes or tanks may be arranged for this operation and there should be a rinse tube after tinting. The amount of film in tinting should be the same as that in developer.

After film has passed through all solutions a squeegee of some character should be provided to remove all surface liquid. It would be desirable to have this a compressed air squeegee (see Fig. No. 8).

Attempts have been made to use a soft rubber squeegee but it would seem that this method is inefficient and dangerous due to any particles of grit which might adhere to rubber, scratching film.

Before we arrive at dry chambers an elevator should be provided which will take care of 20% more film than is in the developer. This will be along the same general lines as (Fig. No. 6). The loops should start from as near ceiling of room as practical. Thus with 12 feet room we may have eight loops dropping down about eleven feet. This would be sufficient for a machine with twelve loops in developer. The function of this elevator is to take care of film when it is necessary to stop the dry chambers due to a break, and if the accident is serious to be able to empty developer before stopping machine. Transmission gearing should be provided at dry chambers so as to be able to stop dry chamber mechanism or to operate it at normal speed, or to operate it at a greater speed.

The dry chambers should provide for four times as many loops as maximum in developer, viz., if you have twelve developer loops you should have forty-eight loops in dry chambers. The method of handling film in dry chambers will have to be different than in wet part of machine, as film during process of drying becomes tacky and cannot safely be passed over rollers with emulsion side in contact. This has been accomplished in a number of different ways. (See Fig. No. 9.) The method illustrated is to have a double roller on the top, and pass the film over the inside one, down and under a weighted roller, back and over the outside upper roller on to the next outside upper roller and so on through the dry chamber.

Another method is simply to twist film. (See Fig. No. 10.) It seems to me that the double roller is preferable as less twisting would occur.

In some machines the lower rollers are individually weighted and free to slide up or down about six inches. In this method every other upper roller has sprocket teeth. Another method is to have eight or twelve lower rollers mounted on a bar which is free to slide up or down about six inches. In this method only the first roller of each unit has sprocket teeth.

The method of handling the air in dry chambers is of the greatest importance. (See Fig. No. 11.)

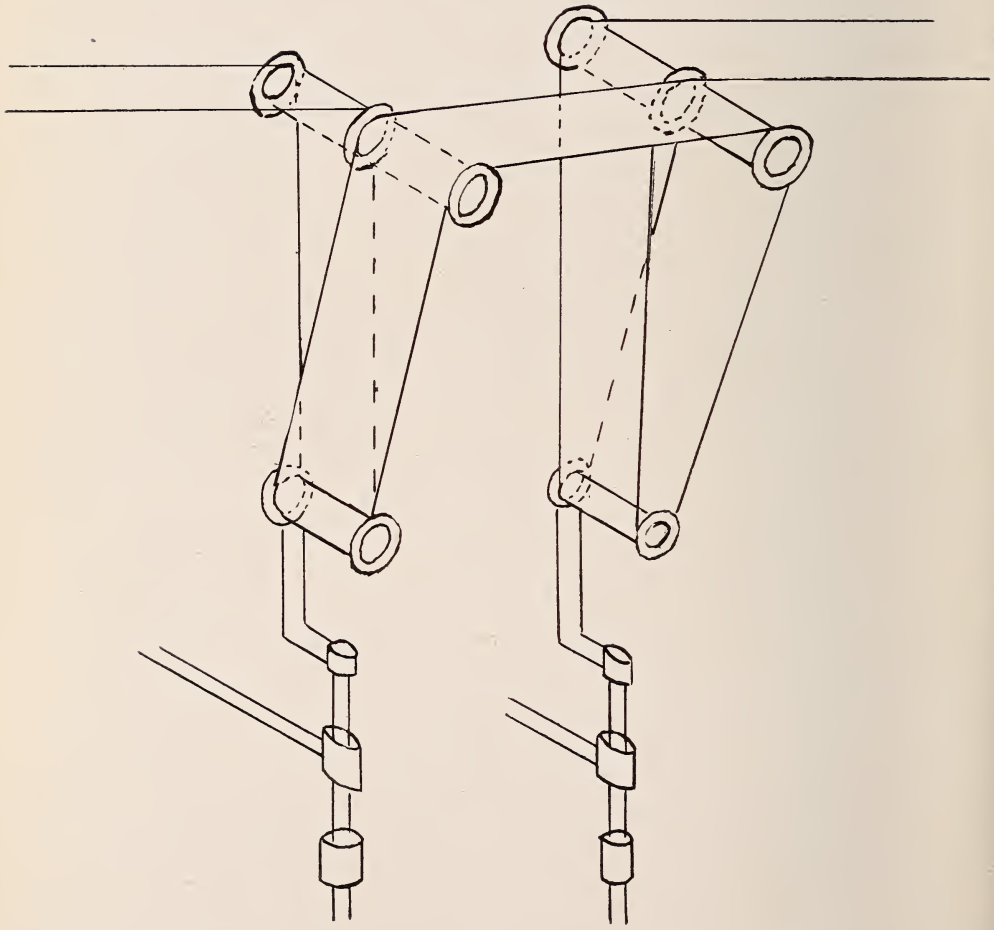


FIG. No. 9. Illustrating Double Roller Method of Handling Film in Dry Chambers.

In this method the conditioned air passes into the bottom of last compartment up over and down through third compartment, etc., until it passes out to exhaust duct at bottom of first compartment.

With a machine having twelve loops in developer you should have at least one thousand cubic feet of conditioned air per minute for each unit of dry chambers which would mean two thousand cubic feet for each double machine.

Suitable friction take up spindle should be provided for reeling up film when dry.

As to materials I would use for frames—channel iron extra heavy hot galvanized. For shafting and gears—monel metal or some other

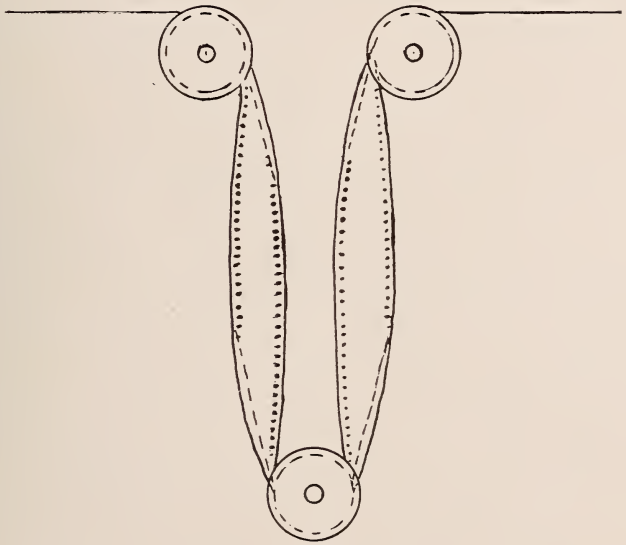


Fig. No. 10. Illustrating Moisture Method of Handling Film in Dry Chamber.

high percentage nickel alloy. For sprockets and idler rollers—hard rubber. For Developer—hard rubber tubes or wooden tanks. For hypo—lead or hard rubber tubes or wooden tanks. For wash—lead or hard rubber tubes or wooden tanks. Dry chambers—galvanized iron with glass in doors and partitions. The subject of corrosion of metals in photographic solutions has been very ably handled in papers by Messrs. J. I. Crabtree and G. E. Mathews—See Industrial and Engineering Chemistry, Vol. 15, No. 7, Page 666 and Vol. 16, No. 1, Page 13—so it would be out of place for me to go into the reasons for using these materials in this paper.

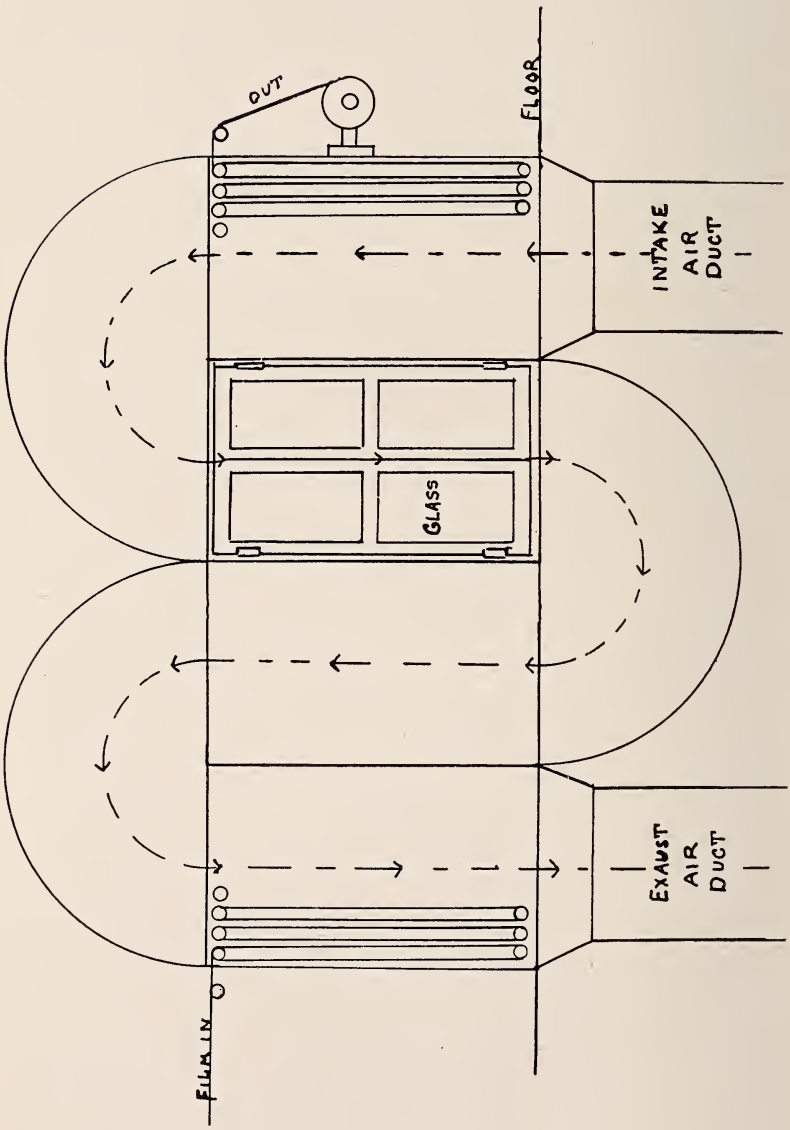


FIG. No. 11.

A point I find to be worthy of consideration in the use of this type of machine is the tendency to carry off the solutions. In one instance with an installation of six machines they are losing 200 gallons of developer a day in this manner. I believe this could be overcome to a great extent by means of placing an air squeegee as the film is leaving the developer solution.

A comparison of tank and tube methods would probably show tanks slightly less first cost and not so readily affected by change of temperature due to slower radiation and greater quantity of solution, while tube method could be cleaned much more readily and would be much more flexible to changes found necessary after first installation. Repairs and replacement cost would favor the tube method.

The developer must always be circulated from a central tank, where temperature and strength may be kept constant. In case of tube method, I should think the hypo should be circulated from central tank. The overflow from the first tube of wash water should be saved for precipitating silver.

In conclusion I will say that this type of machine has been proven thoroughly practical when properly designed and installed.

DISCUSSION

Mr. Crabtree: A very ingenious machine of this straight line type was described in "The Cinematograph Weekly" (Feb. 2, 1923). It differs from the conventional type insofar as the tubes are 30 to 40 feet long, extending into the third story. Such a machine occupies a very small area so that one man can look after it; and by making only a few steps he can observe both the developing and drying. The film is also dried in tubes instead of the usual open cabinet. I should like to ask Mr. Hubbard what he thinks of passing the film through a conditioning chamber after drying. Unless the air supply is carefully controlled by means of an expensive outfit the film will become too dry or too moist so that sometimes a lot of film is spoiled. Profit is largely determined by the absence of loss of film. By using fairly dry air, and then passing the film through a humidifying chamber to get it into equilibrium, with a 60% or 70% atmosphere, it would be insured that the film is in the correct condition after it leaves the machine. If too dry, the wearing qualities of the film are impaired; if too wet, it is likely to stick.

Mr. R. C. Hubbard: First in reference to the long tube, I am afraid Mr. Crabtree does not get the point of the principal objection to the straight line scheme; namely, the fact that your film during development is not easily observed. I have had the opportunity of seeing these machines in operation recently and I find when there is a change in speed due to printing or emulsion, that the operator has slight means of determining this accurately until the film has arrived at the examining light. In a machine with 30 foot tubes, he would have a chance to see the film about one sixth of the time. As far as space is concerned I believe it would be of greater advantage to confine the machine to a room 12 feet in height and for this reason I have recommended loops of 6 or 7 feet in length.

In regard to conditioning the film after it is dry, I don't believe that any special apparatus would be necessary. Very often film does come from the machine in an improper state of dryness. However, all air in a film printing laboratory should be conditioned and as the film goes through the various processes of sorting, assembling, examining, canning, etc. it would have plenty of opportunity to arrive at a state of equilibrium with this conditioned air.

Mr. Vinton: There is one point against the long tube machine of Mr. Lawley's. It is most important to set and keep the tubes dead vertical, and even when correct the film becomes attached to the side of the tube and scratches on the emulsion result therefrom until this clinging of the film to the tube is discovered and the condition corrected. It is difficult to observe this condition until after the film

is dry and when the film once becomes attached to the side of the tube it is very hard to get it away. This defect occurs mostly in the drying tubes owing to the air currents oscillating the film. It is also difficult to recover the film without damage should a break occur.

Mr. Gage: I should like to ask more about the dimensions and the materials of which the machines are made, whether the length of time they can stand alkaline and acid developer is a serious matter.

Mr. Hubbard: It has a very serious effect, there are many points to be considered on the materials question. I did not take this up because Mr. Crabtree and Mr. Matthews have covered it very thoroughly in a recent paper, also I, myself, went into the matter to a certain extent in my paper presented at the Ottawa convention. I merely gave what I thought advisable in this paper using the previous papers as references. I am sure if the materials I mentioned in this paper are used that there will be no difficulty.

Dr. Gage: What is the diameter of the tube?

Mr. Hubbard: Generally about $2\frac{1}{2}$ inches.

Mr. Cook: In a previous paper that Mr. Hubbard had on the subject, also a very interesting one, he did not mention the necessity for variation in the speed of development to counteract differences in printing density, etc. I should like to ask Mr. Hubbard if the more extensive experience has indicated that the time factor is impracticable and if it is necessary to resort to individual judgment again such as we have always used, more or less, in rack development. It has been obvious that in rack development so much has depended on the judgment of the operator in estimating the stage of development in front of the light box. Any effort to get away from this by means of a time factor of a definite number of minutes with developer at a fixed temperature and standard strength would seem to eliminate this human equation. Is it possible that differences in printing may require this individual treatment again? I should like to have this explained a little more fully.

Mr. Hubbard: This opens up a very complicated question. There are so many variables in the process that I don't believe the factorial system would be practicable at present. If we could get a definite instrument for measuring actinic printing light or if we could keep the chemicals in the developing bath at certain definite proportions it might be possible.

When we first commenced to develop by machine it seemed that it would be possible to use the factorial system. We regulate speed of machine so as to begin to show the image at a definite point. We obtained very good results for a time in this way. However, we found that as we added strength to the developer the proportion of chemicals changed so that it was necessary to change our factor, and as we went along our experience showed that the factor would vary from about (4 to 1) to (8 to 1) so we were obliged to fall back on visual observation and judgment.

Mr. Briefer: I think Mr. Crabtree has brought up the most important point in connection with this machine. I spent some time

examining one of these in operation. They work very well, the time of development being regulated by letting some of the rollers come up out of the developer, thus reducing the length of film in the solution. What interested me most was the drying chambers. On this particular day black and white film was going through, also some colored base. I noticed when the reel came out of the drying chamber it wound up octagonally, that is not a very good condition, and if the suggestion which Mr. Crabtree makes, viz. conditioning the film before winding up, proves practical it would go far toward increasing projection life. I believe none of the machines have such an arrangement and I think the plan should be thoroughly investigated.

MR. HUBBARD: I should like to tell Mr. Briefer that in a paper given at Ottawa I explained the condition of air for drying and explained also how we had found in practice that we had to change conditions with the different film. There is no fixed rule about that change, but we have found when the film begins to get too dry we must cut down our conditioning.

MR. BRIEFER: It is clear to me that you dry the film as much as you can and then recondition it.

MR. BROWN: I should like to ask Mr. Hubbard whether he has had any experience in the use of Pinacryptol Green as a desensitizer for panchromatic negative stock. The foreign photographic journals of recent years have mentioned that this dye in a concentration of 1 to 5000 is a most ideal desensitizer and allows working under orange-yellow light.

MR. CRABTREE: I think Mr. Brown refers to the paper I gave on the Rack and Reel Development of Motion Picture Films (Trans. Soc. Mot. Pic. Eng. No. 16 P. 163). Ordinary negative and positive emulsion are very sensitive to Pinakryptol used in the concentration stated. It is possible to examine the film under a Wratten Series 0 safelight after a period of one minute but panchromatic films are not so readily desensitized. The desensitizer may be added to the developer, but too much causes precipitation. The best desensitization we have been able to get with panchromatic film is such that the film can be handled under a deep red safelight such as the Written Series No. 2.

MR. DAVIDSON: I should like to ask Mr. Crabtree if he has had experience in re-conditioning film dried to excess.

MR. CRABTREE: Providing the film is not dried initially at too high a temperature so that there is danger of injuring the base, I do not think that the film is impaired if it is first super-dried and then humidified immediately after.

MR. HUBBARD: In conditioning film I do not think it makes an awful lot of difference after the film goes out because it will take up the condition of the air as soon as it gets out. Only if the film is processed should its condition be very carefully considered.

MR. CRABTREE: I think we have the opportunity of getting an opinion from Mr. Vinton on this matter—as to what results they get

abroad with tube drying as compared with chamber drying. As some of you know Mr. Vinton has made a special trip from London to be with us at this convention and I should like to hear his opinion on this matter.

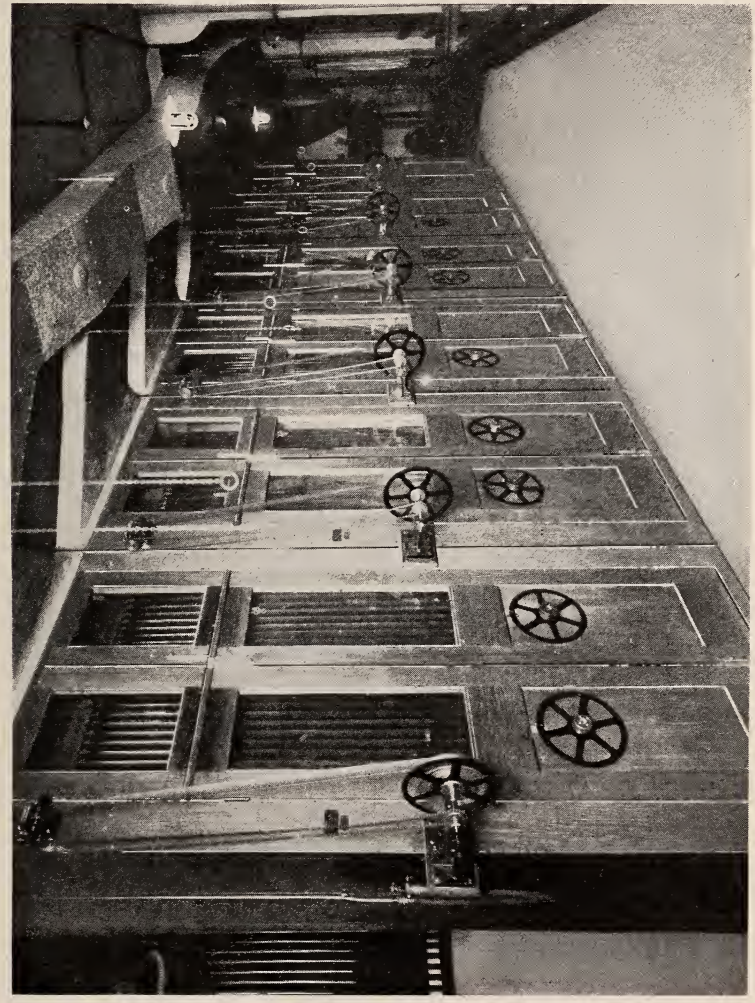


Fig. 1. Film Drying Cabenets.

Mr. Vinten: In complying with Mr. Crabtree's request I only deal with the drying systems of each.

Two systems of general favour in England are Mr. Lawley's tube system and the tank or multiple loop type. Lawley takes the surplus

moisture from the film after washing by a similar means as shown by Mr. Hubbard, except he reversed the process and sucks off the water by creating a partial vacuum inside a tube nozzle, and the outside air passing through the narrow slot with the film sucks off all surplus water; this is very effective. He then loops the film down several 25 ft. tubes, a roller weight keeping the film taunt, and dry air is forced up these tubes until the film is nearly dry; it is then completely dried and conditioned by being looped on a mechanical frame in an open room, where control is maintained on the air humidity. This system is very effective providing the defect of the film getting in contact with the side of the tube is overcome. Two methods are used on the multiple loop or tank system. One is by cabinets; (Fig. 1) in this case the film passes by an air nozzle which blows all surplus water back into the last wash tank,(Lawley having a patent on his vacuum system) and the film enters into a teak cabinet through a narrow slot at one end, the cabinet being 4′6″ long, 20″ wide, and the total height of the room. Double doors closely fitting and glazed run nearly the whole length on each side, and a partition in the center, also glazed but with a 6″ opening at the bottom, divides the cabinet into two compartments. Dry air, which is obtained by drawing it through linen bags and passing it over steam radiators, is fed into the top of the wet film side of the cabinet, the amount of such air being controlled by a valve in the duct, and this air passes down and up the dry side and exhausts at the top. 26 loops in each compartment, each loop being about 18 ft. of film, gives about 800 ft. capacity, the average speed of the film being 25 ft. per minute. It is considered that the air is sufficiently humid after passing through the wet department, to supply the necessary humidity to the dried film. The defects are: insufficient room for ease of manipulation should a break occur; difficult to control the drying to the varying speed of the machine (such machines being varied for speed to comply with developing conditions) and it is not ideal from the fire risk end. These defects were considered by Mr. W. Jeapes and myself, and the following drying plant was evolved and has now been erected by me in a Wardour Street plant. The surplus water is removed in exactly the same way as before, but the whole of the eight drying units are open and installed in one room especially tiled, and all mechanical parts are enamelled white so that the whole room and plant can be washed out by hose pipe. The film comes through the floor from the wet departments and long ducts for it to pass through make it impossible for lighted film on either side to get through. The whole of the mechanical parts (Fig. 2) and the support for the film is on a 4″×4″×3/8″ "U" section girder, 17′6″ long, one end being inserted in rear wall and 3″×3″×¼″ "T" support from floor to ceiling carried the other end, and also carries the vertical driving shaft which is coupled to the wet section by gears and clutch. This shaft drives by means of spiral gears, a lay shaft running the length of the "U" girder and spur gears on same supply the rotation of four sets

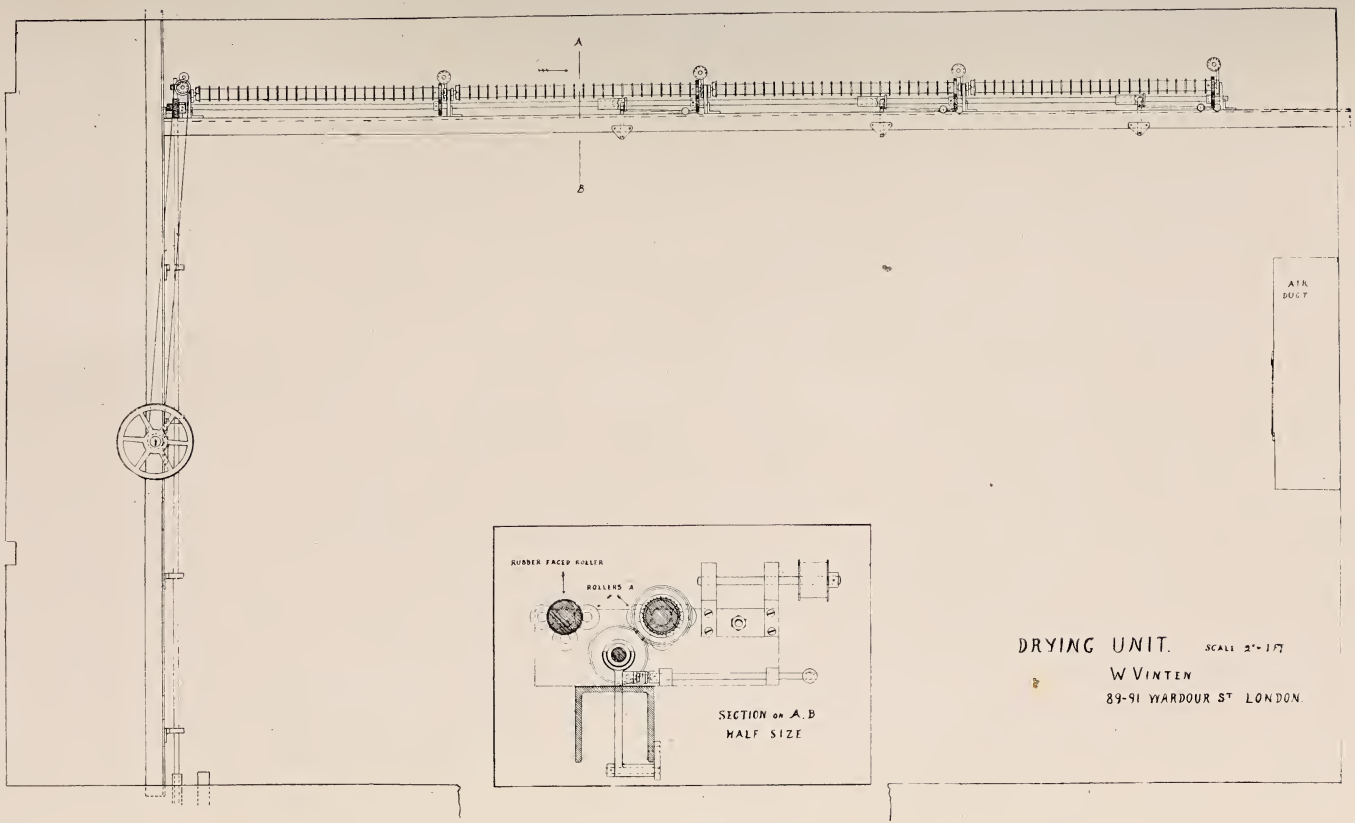


FIG. 2. Drying Rack.

of sprocket shafts carrying 24 sprockets and spacer collars. These sprocket shafts run in rollers as per drawing A and can be lifted out quickly for cleaning, spare ones being inserted while cleaning is in hand. The total capacity of each unit is 96 loops of 20 ft. each, and at 20 ft. per minute speed gives 1 hr. 36 minutes drying time. This is found to meet any conditions which form running speed and to adverse external drying conditions. The air is conditioned as before and is controllable as to quantity from an air duct attached to the flank wall. The air in passing out through windows and around the door cracks excludes all dust that would otherwise enter. Each 25 sprocket shaft can be de-clutched from the lay shaft and the film then taken direct to the rewind, so that the film does not have to travel the full capacity of the machine should it not be necessary. The lay out is such that the operator can immediately get at any portion of the film run should a break occur on any machine, and ample room exists for his free movement. Spacing is run on to the section not required for drying so that should the drying time have to be extended, the picture film can be immediately attached thereto and the drying time extended accordingly with the machine in motion. This is the latest yet accomplished in England and meets all conditions that are required from the authorities, and to the very difficult process of perfect drying under varying film speeds, varying atmospheric conditions, and the exclusion of dust. It being understood that the amount of conditioned air let into the room is to control the humidity only, and the amount of film suspended is to meet the various running speeds brought about by the control necessary on developing.

Dr. Gage's question is met in the following manner. Rustless steel is used for all shafts and enclosed ball bearings throughout. Sprockets are of the built up type, nickel or mono metal discs for the teeth and ebonite collars for spacing these at the correct distance and ebonite spacer washers. Solid ebonite sprockets are also used, and it is surprising the life these ebonite teeth have providing they are not injured by a blow. All these parts are interchangeable so that new ones can be inserted by the maintenance engineer. One of the first of these mechanical plants erected ran for over 8 years and the maintenance cost was remarkably low compared with the film output, it being about 4d. per 1000 ft. including proportion of maintenance engineer's expense. This plant had concrete drying cabinets. A patent was granted to Mr. W. C. Jeapes in connection with same.

These mechanical plants for dealing with the developing, washing and drying are gaining favour in England, as it eliminates the risk of damage caused by handling frames in and out of tanks and from frames to drying drums, and the use of leathers for removing the surplus water. It also eliminates a considerable number of joins in the completed reels and consequently reduces the staff, and they are as equally controllable as the frame method, for a 200 ft. frame must have several scenes requiring different printing values, and not all can have exactly the same developing period.

DIFFICULTIES ENCOUNTERED IN THE ATTEMPT TO STANDARDIZE THEATER SCREEN ILLUMINATION

By R. H. Richardson

WHEN the writer first undertook the preparation of this paper, he proposed to call it "Difficulties Encountered in the Attempt to Standardize Theater Screen Surfaces, Theater Screen Illumination, and Auditorium Illumination." When, however, the first draft was finished it became apparent that (after all) the three items all summed up in one, or very nearly so, so I have taken the liberty of changing the title to its present form.

Before talking too confidently about standardizing theater screen illumination it would perhaps be well to make careful investigation with a view to ascertaining precisely what such an attempt would involve.

In dealing with this subject, it will be necessary to make frequent use of certain technical terms peculiar to photometry and before proceeding further it seems desirable to state specifically the sense in which such terms will be used in this paper.

"Illumination" is used to indicate the amount of light incident upon a surface, therefore, "screen illumination" means the light actually incident upon the screen per unit area.

"Brightness" is used to designate the amount of light coming from, or reflected by, the surface under consideration.

"Brilliance" is used to designate the subjective impression made upon the eyes of an observer. This is sometimes referred to as "apparent brightness," or "subjective brightness," but the term "Brilliance" seems to be preferable. Considering a surface of fixed brightness, the brilliance will depend upon many factors (among which may be mentioned the visual angle) subtended by the surface, the character of the surroundings, glare spots in the field of vision, the previous excitation of the observer's retina, etc.

It is very easy to *say* that the screen illumination should be standardized, but after careful, painstaking examination of the whole subject, we may feel inclined to hesitate because of the magnitude of the task before us. It is even possible we may conclude that the fixing of an inflexible standard is entirely out of the range of practicability. Let us for the moment examine into the problems involved.

It would indeed be interesting to know just how many of the gentlemen who are present would be able to give a satisfactory, offhand reply to the following question.

Exactly what is meant when we speak of screen brilliance?

I trust I may be pardoned for expressing doubt that any considerable number of even this distinguished audience of engineers would be able to reply in a way which they themselves would consider as being unassailable in argument.

My own answer would be that screen brilliance is dependent upon two separate and very distinct factors, viz: (a) the actual brightness of the surface of the screen as measured by a standard photometer, and (b) the effect of this brightness upon the eyes of the average observer. For the purpose of this discussion we will call the former, (a), the Screen Brightness, and the latter, (b) the Screen Brilliance.

We must, however, go still further into particulars in describing item (b), because screen brilliance is itself dependent upon two distinct factors, Viz: (1) the quality of the light and (2) the quantity of light. That this latter is true I think we may all agree without argument. I think we may also all agree that the best "seeing light" —the illumination which makes objects most clearly visible at any intensity of illumination below the point of glare—is the quality of light received from the sun at noonday.

This latter being true, and surely its truth will pass unchallanged, it follows that the more nearly the quality of light incident upon a screen can be made to approximate that of noonday sunlight, the greater will be the visibility of the picture for any given brilliance below the point of glare. Put in another way, the more nearly the characteristics of the light can be made to resemble the characteristics of noonday sunlight, the lower may be the brilliance under any given condition in order to accomplish a given result in visibility of the projected picture.

Exactly what may be the possibilities for accomplishment in the matter of changing projection light tones, or colors, to a value more closely resembling that of noonday sunlight, I cannot, of course say, but certainly it would seem a most promising field for research work by engineering departments of carbon manufacturers and those making incandescent projection lamps.

I might here remark that as long ago as ten years the writer called the attention of carbon manufacturers to the desirability, and as he then believed, the possibilities for improvement in projection light by control of its tones or colors through the use of chemicals incorporated in the carbons, only to be rather curtly informed that the idea was nonsensical, because due to the intense heat of the electric arc, no chemical could or would have the slightest effect.

However, we live to learn and the idea was not as foolish as they then thought. Already much has been accomplished in that direction, and I, for one, firmly believe the end to be not yet nearly in sight. Certainly if ever it is found possible to duplicate for projection purposes the light received from the sun at noonday—and the writer believes that at least a close approximation will eventually be made—it will mean an immense increase in popularity of motion pictures as a form of amusement.

And now let us examine into certain things with relation to screen illumination. Insofar as has to do with an audience, we may illuminate a screen surface to any desired degree within the possible minimum and maximum, and then, without in the slightest degree changing the actual screen brightness as measured by a standard photometer, entirely alter the apparent brilliance. In other words, while holding the actual photometer reading of the illumination constant, we may very greatly vary the effect of that illumination upon the eyes of the observer.

This may be accomplished in any one of several ways. The writer believes he need advance no argument in support of the statement that merely changing the light tone by the addition of color, amber for example, will change the screen brilliance. I think you will all agree that three foot candles of white light will appear to be very much higher brilliance to the observer than will three foot candles of amber light. I believe you will all agree that three foot candles of light from an ordinary arc will not appear nearly so brilliant as will the same intensity with a little blue added. I cite these examples merely to illustrate the difference between actual illumination and screen brilliance.

If it is true that screen brilliance is affected by change in color or tone value of the light, then it would be entirely out of the question to set up an inflexible standard for screen brightness, as measured by a photometer, unless the tone of the light itself be standardized, or unless a different standard be set up for each light tone. The factors of actual light intensity and color values seem to be firmly linked together, and to be inseparable, insofar as concerns screen illumination standardization.

It has, however, been proposed to standardize a certain screen brightness, and then to work from that in the matter of effecting a workable standard for screen brilliance. That this is within the range of possibility I grant, though I am myself unable to see just how it could be applied successfully in practice, because of the fact that so many equations enter, each and all of which affect the final result. Then, too, the color or tonal value of the incident light and the color absorbtion qualities of the screen surface are interlocking factors. Of course the proposed standard would be set up by using a light of known color value, and a screen surface of known color absorbtion qualities. That is easy, but the application of the standard to practical conditions, where not only do we find widely varying conditions, but also those conditions *do not remain a fixed quantity*, seem to me to approach very closely to the impossible. The screen surface which has a certain given color absorbtion characteristic today may, and most likely will have a very different one three months hence. The carbons used today may give off a light of certain tonal value. The make of carbons used may be changed tomorrow, with a very different result in light color value.

Tonal or color value of the light is, however, merely the beginning of our troubles, because the screen brilliance is affected by other

things. As has been said, the color absorbtion value of screen surfaces is one of them. Another factor which must be reckoned with is the reflective characteristics of the screen surface. This is indeed an important item, though one which has mostly to do with width and depth of the theatre auditorium, or more correctly speaking, with theatre seating space. This item has, I think, little or nothing to do with standardizing screen brightness, but most emphatically this society should formulate certain standards for screen surfaces in the matter of diffusion of light. There should, it seems to me, be a surface of certain very definite characteristics for theatres having various viewing angles, both sidewise and up and down. It is true that much has already been accomplished in this direction by this society, working in collaboration with various manufacturers. I think, however, there is very much more still to do. In fact I believe the work is just well begun, and that until we are able to recommend a certain definite surface, or a surface with certain well defined characteristics for each lateral viewing angle, for each lateral viewing angle and maximum viewing distance and for each maximum lateral angle, maximum viewing distance and perpendicular viewing angle, the work cannot be called finished. But all this has little, if anything to do with the thing we are discussing in this paper.

Screen brilliance is very greatly affected by contrast of the screen surface with its immediate surroundings. That this is true you all well know.

If we were to project a picture eighteen feet wide in the center of a white plaster wall thirty feet wide by twenty high, without any sort of contrasting border, it would be found that it would be very difficult to make the picture appear brilliant to an audience. If, however, we cover the entire wall outside the picture with black cloth, or paint it black or a dark color, the picture will immediately, without any change in actual illumination, appear to be very much more brilliant. This is because we have introduced contrast.

As a matter of fact a really brilliantly illuminated picture projected to a white wall without a contrasty border appears not only far from brilliant, but also has the appearance of being "faded." Its blacks do not have their true value. I do not know just why this should be so, but I do know it is so for I have seen it demonstrated many, many times in the old days when a border having contrast with the screen surface was the exception and not the rule. It therefore follows that in order to set up a standard for screen brilliance we must stipulate exactly what the screen border and immediate surroundings shall be, else the net result will change with every variation thereof.

Still another element to be reckoned with is auditorium illumination. Nothing affects screen brilliance more quickly than glare spots within view of the eyes of the observer. If we expect to secure a given result from any standard we may set up for screen illumination density, we must, as a part of our programme, eliminate glare spots.

The rear of an auditorium may be well illuminated, provided no direct rays from any lamp be permitted to reach either the screen or the eyes of the audience. Such illumination must, however, be gradually diminished toward the front of the auditorium. It seems unnecessary to set before you the very damaging effect light in the front of an auditorium has upon screen brilliance. You all know as well as I do how it "kills the picture," so why waste effort. I will, however, call your attention to the fact that there is such an intimate connection between the general illumination of the front of the theatre auditorium and screen brilliance that standardizing the auditorium illumination becomes, in the very nature of things, an integral part of standardizing screen brilliance. Also it must be remembered that there is a wide range of reflective value of walls and objects in different theatres and the finish of them will affect the color of the light reflected from their surface. This item may be of minor importance, but it nevertheless affects the result as a whole, in some degree, by reason of the fact that such rays reach both the screen and the eyes of the audience.

We may therefore begin to see what a truly colossal task is before us when the attempt is made to standardize screen brightness in a way which will cause all theatre patrons to observe the same thing insofar as has to do with screen brilliance.

One hugely important thing I very nearly overlooked, and that is viewing distance. It is a well known and recognized fact that an entirely different actual screen brightness is necessary to the patron seated fifty feet from a screen and one seated one hundred feet therefrom. That this is true I think you all know, and certainly it cannot but be a very difficult point when we attempt to set up a standard which must be used under both conditions. That it may be taken care of by the reflection characteristics of screen surfaces is possible, though I doubt it.

Were all theatre auditoriums one size and shape, all projection light sources of one color or tone value, and all eyes essentially the same in the matter of interpreting light intensities, then the standardization of screen brilliance would be an easy matter. As things really are however, it seems to me that an inelastic standard for screen brightness (apparent or actual) is not quite a practical thing.

In attacking the problem it would seem to me the very first task would be to ascertain by experiment exactly what screen brilliance is most comfortable to the average eye—an undertaking of some magnitude in itself—and what, if anything, it is practical to do to produce the same result in brilliance at different distances from the screen.

This paper is brief. Its preparation was undertaken rather late, when it seemed our spring program of papers might not be complete. A subject of this magnitude demands much effort and time. I have done the best I could under the circumstances. The paper is written mostly with view of provoking discussion by men here

present who are much more competent than am I to say what is probably the best line of procedure in the effort to effect a workable standard of or for screen brilliance.

Possibly it would be good proceedure on the part of our President to appoint a very carefully selected special committee to consider this whole matter, and make report to our fall meeting as to what it seems practical to do to effect such a standard.

DISCUSSION

Mr. Briefer: I haven't much experience with problems in projection and screen brilliancy; I will say only a little from the viewpoint of the audience seeing the picture. Pictures are fashioned very much to please the tastes of the public as developed by their support or preference for the things they have seen. Very few pictures projected are really black and white; most of them are tinted to favor the condition under which the picture is supposed to have been taken. Colors vary, and it does not seem possible, from my viewpoint, to provide any kind of standard in the manufacture of screens or in considering the relative photometric values of the light reflected from the screen under the conditions approached in the projection of pictures today. You have nine or ten colors; 80% of the pictures on the screen are tinted. We do not deal with white light any longer. As soon as we get away from white light, we also get away from the objectionable features of harsh screen projection. The lighting effects are being improved. The broad expanses of hard highlights and inky shadows are things of the past. The Art and Science of motion photography are more nearly in step, so that the question of illumination, screen brilliancy, and screen convenience is working itself out without effort on our part. The public is showing a marked tendency to support what is best in the matter of screen projection.

Mr. Egeler: The previous speaker stressed the thought that we have a big problem in trying to standardize screen illumination. As a step toward simplifying the task, I would call attention to the fact that we can reduce the more important factors we are dealing with to a relatively small number, and express them in units already employed in illuminating engineering. First is the amount of light directed to the eye. We can measure this in terms of the brightness of the screen, for the type of illumination used. Regardless of the amount of light put on the screen, that which affects the eye is only the light reflected back from the screen to it. Another factor is the extraneous light reaching the screen. A third would be color; here the psychological side is also a factor; that is, one color appeals differently from another. A fourth factor is the size of the picture and the position of the observer in relation to it.

I think brightness enters in principally, in relation to the size of the picture observed. If we are trying to see a picture at different distances, we require greater brightness at long distances than at short ones. Other factors enter in which I shall not try to discuss in detail here. As a single example, the point was brought out that we have the greatest contrast when the surroundings are not distinctly

visible. It is generally accepted, however, that within certain limits the ease with which seeing is accomplished becomes greater when the brightness of the field surrounding the object being viewed, is increased. This would substantiate consideration of well illuminated surroundings for the screen. I will not attempt to enumerate all of the factors to be considered, but I suggest that in any analysis of the subject, the several factors be segregated and the variables expressed in the generally accepted units now used in illumination work.

Mr. Manheimer: Mr. L. A. Jones presented a very good paper on this subject at the Dayton meeting in connection with illumination of motion picture theaters. It was a very interesting paper and perhaps he would say something now.

L. A. Jones: Mr. Richardson has presented a very interesting paper and while I do not agree with everything he has said, I believe the paper has a great value in that it brings these things before us encouraging thought and discussion. In the first place, I should like to call Mr. Richardson's attention to a matter of Nomenclature. The Illuminating Engineers and those who have specialized in the field of photometry have adopted very definite terms for use in expressing many of the things with which Mr. Richardson deals in his paper. It seems to me that in order to make this paper the most valuable and most easily understood it would be well to use the terminology of the specialists who have worked along these lines and to adhere as closely as possible to the Nomenclature more or less officially recognized. In many places I think the paper is somewhat confusing simply because I do not understand exactly what Mr. Richardson means by some of the terms used. I do not agree that the standardization of projection conditions is an impossible task. I grant that it is somewhat complex and presents many difficulties but when our knowledge of the requirements is more complete and possibilities for control of conditions is increased, I believe that the desire for standardization can be accomplished.

It seems to me that the ultimate end to be attained in the projection of a motion picture is a picture of proper brilliance combined with satisfactory definition and color. It is true that this brilliance depends not only upon the screen brightness but upon the condition of the observer's eye as determined by the general illumination to which that eye is adapted. It is entirely possible to measure with relatively high precision the screen brightness and it is possible to determine the adaptation level of the eye under specified conditions; and it is likewise possible to determine the brilliance of the picture. We can determine the effect of a given room illumination is upon adaptation level. It seems to me that while there are many factors which must be considered, every one is capable of measurement. It is only necessary therefore to properly combine and evaluate these various factors in order to obtain the desired results.

I want to point out also that there is in the literature a vast amount of information applicable to this problem. The psycholo-

gists and physicists have made extensive studies on the effect of various intensities and qualities of light upon visual acuity and brilliance. It is quite possible to measure the relative brightness of surfaces differing widely in color. I think Mr. Richardson has exaggerated the difficulties. I admit they are great but standardization of these factors is not impossible.

Mr. Richardson: With relation to the terms I make no pretense of being familiar with them. If they can be improved upon, I should appreciate it if before printing Mr. Jones go over the matter and put them in proper form if it can be done.

THE EFFECT OF SCRATCHES ON THE STRENGTH OF MOTION PICTURE FILM SUPPORT

By S. E. Sheppard and S. S. Sweet

THE work dealt with in the present note was mainly confined to an investigation of uncoated, unprocessed standard perforated motion picture film support which was specially prepared for these tests. The apparatus employed consisted of the following:

A. An elongation and strength testing machine with automatic recording device.
B. A fold tester.
C. A scratch tester.

The procedure consisted in scratching the support by the aforementioned scratch tester, which produced a definite scratch under a known load. The test pieces thus prepared were then examined both for mechanical strength in apparatus A and for number of folds; that is, for flexibility, in apparatus B. The apparatus A for determining elongation and tensile strength was a machine of the Schopper type of paper tester provided with a special automatic recording device by means of which the whole elastic curve of the film could be plotted. In operation a sample of the material to be tested is locked between two jaws, one of which is pivoted to a weighed lever and the other is mounted at the top of a vertical traveling screw. This screw is lowered by a constant speed motor operating through a suitable train of gears and in so doing submits the sample to a stress proportional to the angle which the weighted lever at any time makes with the vertical. The movement of the lever and the elongation are recorded on a drum which is positively connected with the lever. The pen of the recorder does not travel continuously over the recording paper but marks this intermittently by means of an electric clock making normally two point records a second or changing according to the period impressed upon it by the electric chronograph attachment. This enables the rate at which the stress is applied to be automatically taken from the records.

The accompanying diagram (Fig. 1) shows the type of record obtained and the characteristic elastic curve of the material. Loads are recorded to .02 kilograms and elongations to 0. 1 mm.

It is not necessary to describe the folding tester in detail. It consists in an arrangement for bending the film reversibly to a fold through a sharp angle and recording the number of times of folding until the film fractures.

The scratch tester consisted of an apparatus for drawing a

point of definite character across the surface of the film under a known load.

Experimental Results

In the first series of experiments the scratches were made at right angles to the principal dimensions of the test piece. This was 19 cm. in length by 1.3 cm. in width. The following table shows the results obtained with cellulose nitrate base (fig. 2) and the curve (Fig. 3) shows that there exists a steady relation between the scratch load and the breaking load. It appeared from this that small scratches such as occasionally occur on film and which may be sufficient to mar it for projection have little or no effect on the strength of the support, since the break load did not change appreciably until a load of more than 200 grams had been applied. This was then tested fully over a wider range of material and with a greater variety of conditions and measurements.

In the second series of experiments, three types of material were used; namely, cellulose nitrate film, an acetate film support with gelatine backing, and a plain cellulose acetate film support. (Figures 4 and 5.) The number of folds on the folding tester were checked up against the previous results for the breaking strength. In this case the fold was made exactly along the line of the scratch. Fig. 6 shows that the folding tests with nitrate support do not differ very greatly from the tensile strength tests but show a somewhat greater dependence of the folding resistance upon the scratching than the tensile strength.

Series 3 experiments were made solely with the folding test with lateral scratches, and as shown in the next slide (Fig. 7) they illustrate very much the same type of relation between the number of folds and the scratch load; at any rate, within the regions of scratch loads which would be of any practical importance.

Effect of Position and Orientation of the Scratch

In experiments in which the scratch was made in the direction of the principal dimension of the test piece and between the perforations, only a small effect is shown by the folding test even for very heavy loads and deep scratches, the number of folds decreasing only about 15% for a scratch load of 1170 grams.

In a further series of experiments lateral scratches were made on perforated acetate film which had been coated with emulsion and processed, the length of the scratches and their positions with regard to the perforations being changed. This is best shown in the following two figures (Nos. 7 and 8). It is also brought out diagrammatically in the graphs given in Fig. 9.

These last results indicate that scratches on film support must extend nearly one inch before the strength of the support is appreciably affected even at as high scratch loads as 500-700 grams.

Conclusion

The general conclusion from this work is that the idea sometimes expressed that the mechanical strength of such materials as celluloid and similar plastics is greatly dependent upon superficial scratches and a surface skin does not hold for motion picture support. It appears from this that the principal effect of the scratch is due to its depth affecting the thickness of support at a given point and consequently reducing the effective thickness. Characteristic effects are shown in regard to the position of a scratch in the neighborhood of perforations which are such as would be expected, but practically all the scratches which were operative in the present work were well beyond the depth and intensity of scratches appearing on motion picture film support.

Rochester, N. Y.
May 10, 1924.

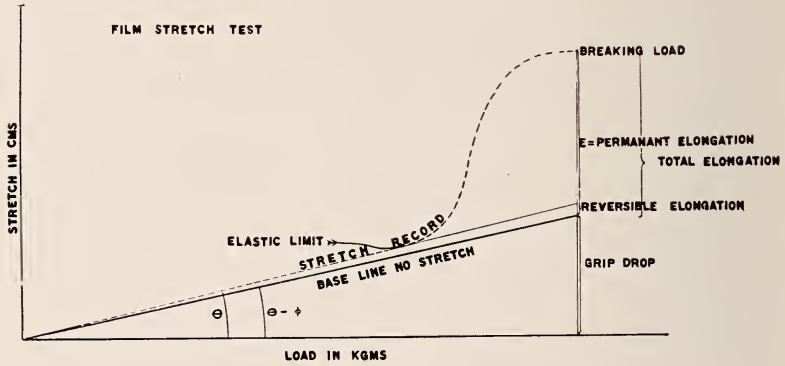


Fig. 1.

Table 1

Load in gms. on Scratch Tester	*Breaking Load on Film Tester*	*No. Folds on Folding Tester*
0	11.0 Kg.	325
200	10.0	325
250	9.5	320
320	9.8	267
390	8.65	248
470	8.5	245
560	7.5	245
670	7.5	200
780	7.5	190
930	6.3	150–108
1080	4.8	76–100
1270	1.6–3.2	46–60

Fig. 2.

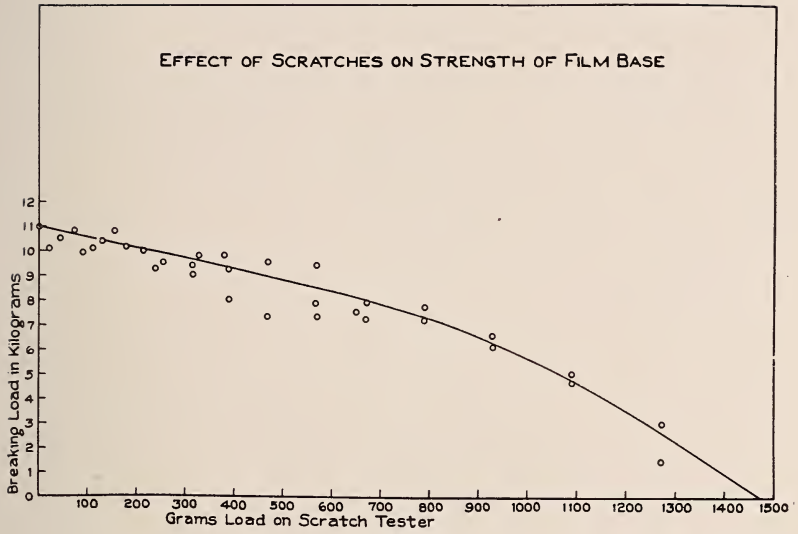


FIG. 3

TABLE 2

Load in gms. on Scratch Tester	*Regular Nitrate No. 58-714*	*Safety Backed No. 16-6468*	*Cine Kodak No. 16-6032*
0	325	250	175
200	325	222	164
250	320	220	150
320	267	225	138
390	248	220	140
470	245	180	146
560	245	170	140
670	200	169	130
780	190	111	126
930	150	60	76
1080	76	42	66
1270	46	16	50

FIG. 4.

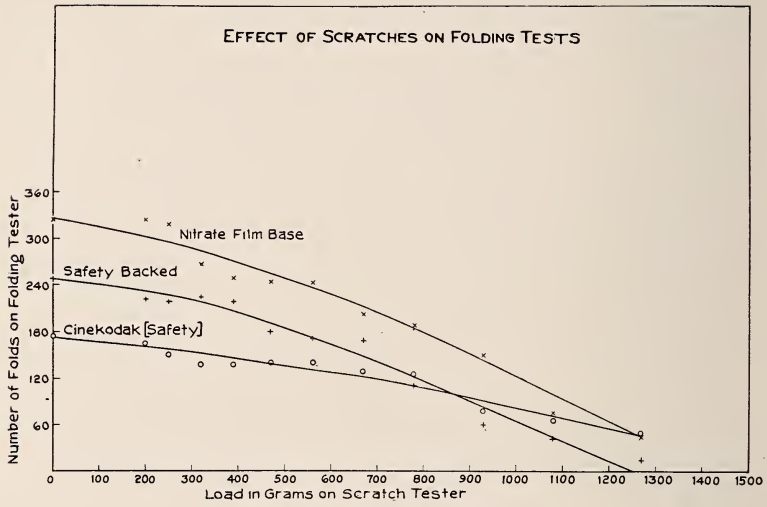

EFFECT OF SCRATCHES ON FOLDING TESTS
Number of Folds on Folding Tester
Load in Grams on Scratch Tester
Nitrate Film Base
Safety Backed
Cinekodak [Safety]
360
300
240
180
120
60
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

FIG. 5

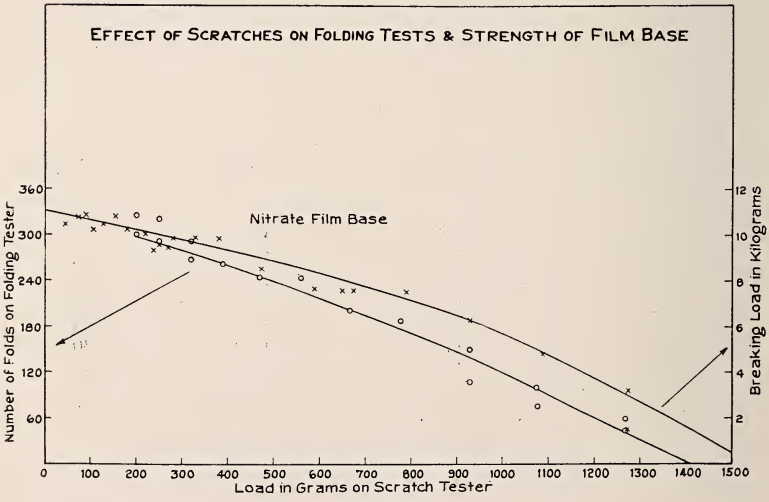

EFFECT OF SCRATCHES ON FOLDING TESTS & STRENGTH OF FILM BASE
Number of Folds on Folding Tester
Breaking Load in Kilograms
Load in Grams on Scratch Tester
Nitrate Film Base
360
300
240
180
120
60
12
10
8
6
4
2
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

FIG. 6

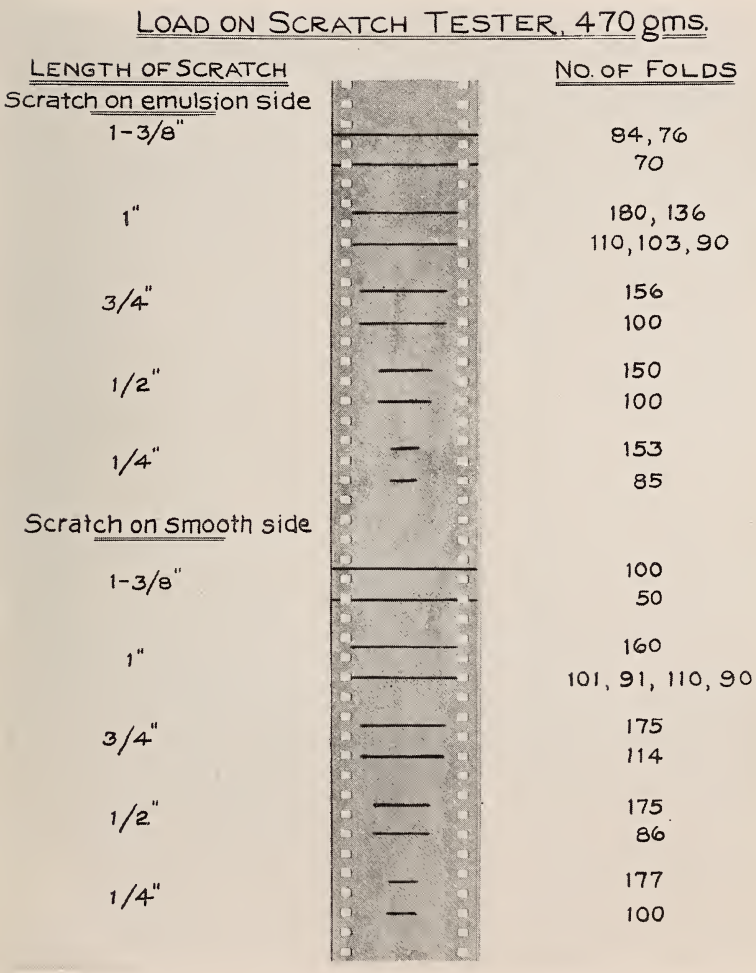

LOAD ON SCRATCH TESTER, 470 gms.
LENGTH OF SCRATCH
NO. OF FOLDS
Scratch on emulsion side
1-3/8"
84, 76
70
1"
180, 136
110, 103, 90
3/4"
156
100
1/2"
150
100
1/4"
153
85
Scratch on smooth side
1-3/8"
100
50
1"
160
101, 91, 110, 90
3/4"
175
114
1/2"
175
86
1/4"
177
100

Fig. 7

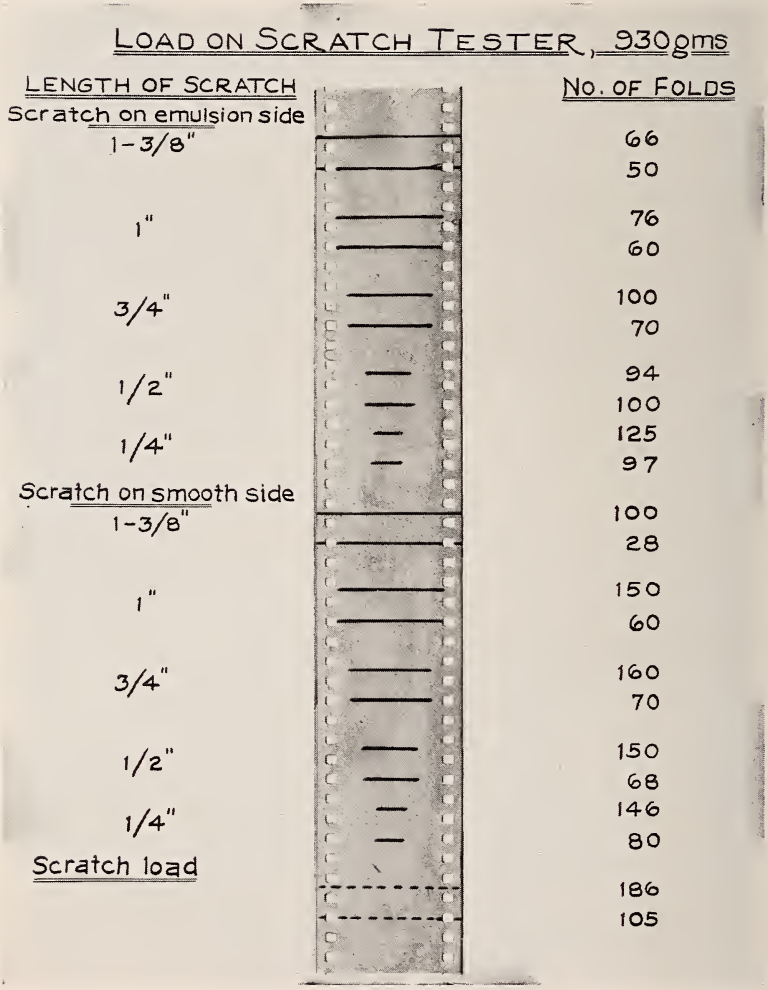

LOAD ON SCRATCH TESTER, 930gms
LENGTH OF SCRATCH
NO. OF FOLDS
Scratch on emulsion side
1-3/8"
66
50
1"
76
60
3/4"
100
70
1/2"
94
100
1/4"
125
97
Scratch on smooth side
1-3/8"
100
28
1"
150
60
3/4"
160
70
1/2"
150
68
1/4"
146
80
Scratch load
186
105

Fig. 8

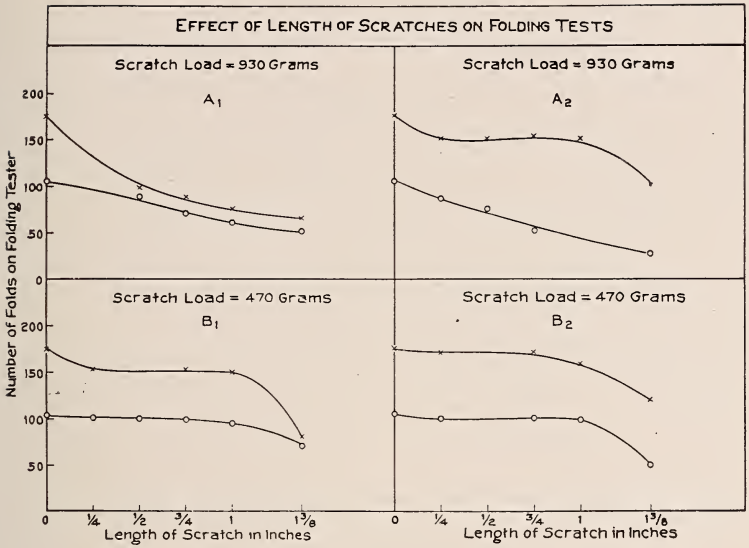

EFFECT OF LENGTH OF SCRATCHES ON FOLDING TESTS
Scratch Load = 930 Grams
A1
Scratch Load = 930 Grams
A2
Scratch Load = 470 Grams
B1
Scratch Load = 470 Grams
B2
Number of Folds on Folding Tester
200
150
100
50
0
0
¼
½
¾
1
1⅜
Length of Scratch in Inches

FIG. 9

DISCUSSION

MR. BASSETT: I should like to ask whether the age of the film and its brittleness would not change the readings, that is, as it became more brittle it would be more like glass and surface scratches would have more effect.

MR. CRABTREE: Yes, it would have a very great effect. All the tests were on new stock.

MR. L. A. JONES: All tests were made on material in a certain fixed condition and designed to show the effect of different sources, size, and depth of scratches. The age of the material has not been considered in this paper. I think Mr. Briefer dealt with this in his paper.

REQUIREMENTS OF THE EDUCATIONAL AND NON-THEATRICAL ENTERTAINMENT FIELD

By W. W. Kincaid

THE Standardization Committee of the Motion Picture Chamber of Commerce, made up of agencies that are interested in developing the motion picure service in the non-theatrical field, was formed for the purpose of setting up standards for the efficient operation of the portable motion picture projector. It is the purpose of this Committee to set up operating standards to meet conditions which usually occur in lodge rooms, churches, schools and other places in which the non-theatrical exhibitor is called upon to show film.

It is our purpose to instruct the non-professional operator how to detect and meet these conditions and secure as nearly as possible 100% efficiency. This operator must be made to appreciate the conditions which he has to face and must be taught to adjust his equipment so as to meet these conditions successfully.

Your Society has pioneered the way by working out the laws and principles of the movie projector, including the principles of light and the laws and principles of reflection qualities of screens. This work is certainly not only helpful but indispensable, if progress is to be made along the line of scientific development of the industry.

If all of the operators in the non-theatrical field were trained in their work we would experience satisfactory projection on the screen and the work of our Committee would be unnecessary. The outstanding fact is that most of the institutions and societies in the non-theatrical field must rely for operators upon some one of their number and one who has not been sufficiently instructed in either the operation of the projector or how to judge and meet the conditions with which he is confronted.

While it is true that the manufacturers of projectors and equipment supply books of instruction with their machines, they usually fail by going into too much detail about particular operations. On the other hand, they do not give necessary instructions on how to study conditions commonly met in setting up and operating the equipment. Some information regarding the usual conditions which are found in the average lodge room, church and school room must be pointed out. The operator must be taught how to judge of these conditions and how to successfully meet them. He must know the maximum efficiency as well as the limitations of his projector. He must be taught how to coordinate and operate the three elements necessary to produce a satisfactory picture—the projector, the screen and the film. He must be taught to survey the conditions under

which the exhibition is to be given; the seating of the audience, the lighting, size and proportion of the room and their relation to the projector and screen.

In attempting to help this amateur who has just been assigned this responsibility in his society, we have a real problem. We must explain as far as possible in non-technical language, which he will understand, the simple processes and steps to be taken. If the person selected happens to be an engineer or one who has received a technical education the process is simplified. Usually, however, the one selected has not had a technical education. Quite often the Master of the lodge, the Minister of the church or the Principal of the school is assigned the responsibility of setting up and operating the equipment. Often the one selected is a young man with no technical education or experience.

If we could adopt in a large measure the technical language of the engineer, the books and papers written by the members of your Society would afford an abundant source of information and could be used as presented in our course of instruction. These papers and articles must ever be a fruitful source of study to the one who has passed through the early stages of experience in operating motion picture equipment.

It is the object of our Committee and the Motion Picture Chamber of Commerce, therefore, not to substitute the work of the Society of Motion Picture Engineers. It is rather our purpose to gather correct information from all sources regarding the study and overcoming of conditions in the setting up and operation of equipment in brief, simple language for the beginner. In doing this we must express ourselves, even at the risk of being unscientific in our statements, in language which the novice understands. Although the language employed may not be the best from the scientific standpoint we still hope to convey to this beginner an intelligent conception of the first steps to be taken in discharging his responsibility.

The work of our Committee has not progressed to the point where we can present to you a copy of our findings or recommendations. We feel that much can be gained by close cooperation between your Society and the Motion Picture Chamber of Commerce. We feel that our Committee has been aided materially by contacts which we have had with individual members of your Society who have volunteered their services in helping us in our work. We invite the closest cooperation between your Society and our parallel committees so that the work which we do may not only contain the desired simplicity and meet the understanding of the beginner but that it may also be sound in principle and scientifically correct.

The manufacturers of equipment and the distributors of film are greatly handicapped at the present time by the lack of general information on the part of the public regarding the selection and operation of motion picture equipment. The results obtained from

the average screening by the amateur operator are less than 50% of normal efficiency. The success of the distributor of films in the non-theatrical field is conditioned upon our ability to instruct beginners in the operation of our equipment so that they will project on the screen pictures that are satisfactory to their audience. To accomplish this distributors of film and equipment must cooperate in educating the beginner to the degree of efficiency necessary to attain the desired result.

It is for the purpose of extending the information regarding the use and operation of the motion picture equipment, thereby insuring a wider circulation of clean, wholesome motion pictures for educational and community entertainment purposes, that we as a Chamber of Commerce devoted to the non-theatrical field have undertaken to popularize this information. In the interest of education and of greater service to the public we ask your sincere cooperation.

DISCUSSION

L. A. Jones: I think we are to be congratulated that Mr. Kincaid has come to us representing the Motion Picture Chamber of Commerce of America Non-Theatrical. I think one of the things this society should stand for is whole-hearted co-operation between every organization in the motion picture industry. The paper is before you for discussion, and I hope we can have a good discussion on this subject.

Mr. Richardson: I believe Mr. Kincaid has put his finger on the key to the whole situation. You are getting to a large extent the inefficient results you talk of for one reason, and that is that you do not talk about the projection of the picture but the operation of an equipment with the result that your amateur gets the idea of merely operating a mechanism and does not go beyond that. There are many things connected with the projection of motion pictures and it is not true that the man has fulfilled his mission when he has "made a lot of wheels go round" for he has overlooked more important elements of projection such as the size of the room, angle of projection and other things. Therefore I say you have put your finger on the button controlling the whole thing. I have actually had men inform me I was a lunatic when I said there was anything to projecting pictures besides operating a bit of mechanism. If you would talk about projection of pictures, you would convey an entirely different viewpoint to the amateur.

Mr. Cudmore: It may be of interest to this body to know that in the past several months a very strong movement has been started to enlist the assistance of the projectionists' union in co-operating in the principal cities with motion picture supply dealers for the purpose of securing this professional knowledge that Mr. Richardson talks about so frequently so that the inexperienced church pastor or school superintendent might have the assistance of these expert projectionists that are either employed by the nearest supply house or by the local unions when they have a picture to project. We know that the strongest union we know of is the International Theatrical Stage Employees and Moving Picture Operators generally known as the I. A. T. S. E.

Mr. Richardson has not yet changed their name to projectionist. It seems to me from the several months' study I have made in the United States that it is in order, if there is nothing to prevent it, to extend an invitation to this body of union men, this large organization, to invite them to appoint a delegate to come to our meetings and not only to co-operate with us but with the Chamber of Commerce

in working out this problem, because it is beyond the capability of the non-theatrical companies to do it themselves. Very few have expert projectionists and they have operated by advertising the pictures, but as Mr. Richardson has pointed out they have talked about selling a machine, and the result is that they get this 50% efficiency on the screen or even half of that. It is a vitally important question and we are at the cross-roads to-day. It is just as important as getting the right picture in any large theater.

Mr. Beatty: It was the feeling among a number of those engaged in the non-theatrical industry, that the time had come for our recognition as an industry that some year and a half ago caused the formulation of the Motion Picture Chamber of Commerce of America, Non-Theatrical, Inc. The Chamber has grown rapidly and now numbers among its members the leaders in the various branches of the industry. Perhaps some of you do not know much about the Motion Picture Chamber of Commerce of America Non-Theatrical, Inc. and I should like to speak briefly to you about it.

This organization comprises the manufacturers and distributors of non-theatrical motion picture films, together with the manufacturers of projector machines, screens and various motion picture accessories, as well as others who may be interested in various ways in the furthering of the use of motion pictures outside the theatre. We number among our members practically all of the leaders in these various lines of endeavor, and a great number of corporations outside the industry that are using motion pictures in various ways in their business program. We also have as associate members a number of national welfare organizations, with whom the use of motion pictures is growing more important every day.

We act as a clearing house for authoritative information for these bodies, and for that reason, the committee of which Mr. Kincaid is the chairman has labored unceasingly to standardize practices in order that we may furnish authoritative and intelligent information to them, that will assist them in their motion picture programs.

We have been vitally interested in a bill to remove burdensome restrictions now existing on acetate film. The bill was a composite bill, and we secured, in helping us to draft it, the National Fire Protection Association, National Educational Association, Visual Instruction Association of America, Motion Picture Producers and Distributors of America, Inc., and the Eastman Kodak Company. We realize fully that at this time it is impossible for the entire motion picture industry to be placed on an acetate basis. So in order not to interfere with the existing conditions, we introduced this bill which provided for the regulating of nitrate by a system of permits to be issued by an administrative body of the State, which made it impossible to get a print on nitrate film without a permit which would only be issued where the exhibitor had complied with the same law that governs the theatres. We felt that by having prevented the

amateur from being able to get nitrate film we were therefore entitled to the free and unrestricted use of acetate. This bill was introduced at Albany and passed both branches of the Legislature, but for reasons, which it is unnecessary to state, was vetoed by the Governor who gave the most ridiculous reasons for his veto. The thought in our minds was, that by releasing acetate from these burdensome restrictions, the entire non-theatrical industry would be benefited, additional quantity of acetate would be used, which would allow the manufacturers to continue their experiments and build up quantity, production, improve the quality of the film, so that when the time comes, if it ever does, that the entire industry is compelled to go on an acetate basis, the manufacturers will be ready. It was not selfish to ask for this bill. It is for the benefit of the entire non-theatrical industry, for the benefit of the Nation, the church, school, and the industrial concerns that wish to use motion pictures.

I have copies of this bill with me, and will be pleased to give one to everyone who is interested, and I feel that you all are, as it is a matter of vital concern to the entire motion picture industry.

Mr. Richardson: I should like to say to the secretary of the Chamber of Commerce Non-theatrical I am for a bill of that kind, nevertheless I helped to defeat the one you proposed. You are ignoring thirty-four thousand men who are vitally interested. You did not consult them, and that we object to. In my opinion the bill as drafted was very unsafe. I have expended much energy in trying to help the amateur, and anything I can do in my humble way to assist the Chamber of Commerce in the education of the amateur I shall be very glad indeed to do.

Mr. Cook: As another member of the Motion Picture Chamber of Commerce, I want to point out that there is available a considerable amount of very helpful literature along the lines indicated by Mr. Kincaid, popularized knowledge for the use of prospective projectionists. There are two very excellent books by Lescarbowra of the Scientific American Publishing Company containing all the popularized knowledge that a projectionist is likely to take the necessary time to absorb and apply. Going further, there are the more elaborate technical works of several of our members, up to the encyclopedia of Mr. Richardson. That, I think, is altogether too ponderous a volume for the ordinary projectionist to master in its entirety. There is a useful book by Henry Bollman on "Community Motion Pictures." A book published by Lippincott is more elaborate in its formation than those of Lescarbowra. Very much of this work that the Motion Picture Chamber of Commerce is setting out to perform has already been performed for them, and the application and use of it will save the wasteful duplication of effort however well intended it may be. These books supply most of the information needed in our field of less technical nature than that in our Transactions.

Mr Kincaid: I thank Mr. Cook. We are not interested in publishing a large book. Our first step I think was expressed by

Mr. Richardson better than I could express it. We want to get the best picture possible on the screen—everything that will contribute to better projection—that is what the committee was appointed for, and the point is to get the amateur started right. I don't think we could get any amateur to read the books first. What I would like to see us get together is a brief manual or leaflet. Many projection manufacturers do furnish a manual with a projector, but it is not brief enough and touches only on running the machine, which has little to do with getting a 100% picture. The whole story is that a man must have a little knowledge of the room, the distance which he must throw, etc. What we don't want to do is to make him throw a long distance if this is not necessary.

Mr. Cudmore: There are two very vital points on this subject from my point of view from personal investigation with some of the leading men at the head of this national union. The first and principal point in my opinion is that the manufacturers of projectors cannot hope to get them into general use in the principal cities until they take into their co-operation the men who ran this International Union; they are not going to stand for creating projectionists in churches and schools. If this society means what they say, that projecting pictures on the screen is a science and not running a mechanism, if that is a fact, and you mean what you say, then these skilled men who are being paid from $48 to $75 a week must be given consideration; if not, they will throw sticks into your wheels as fast as you turn them around. We have overlooked the biggest bet. As a new member of this society you have a man who knows more about the motion picture projectors than anybody I know of, and much to my surprise I find that these union men want to co-operate. They see in this co-operative movement a chance to keep this skill and science within themselves, and they will help appoint committees to teach these new operators how to put the picture on the screen. There is a movement on foot to make projectionists pass an apprenticeship.

The second point is that the portable machine manufacturer should cut out of his advertising the statement that anybody can run a motion picture machine, It cannot be done; they can run the machine and put through the film, but it is not a picture comparable with what people see in the theaters, and after all the non-theatrical user is directly or indirectly in competition with the local theater, therefore, the quality of the goods must be equal if they are going to get the business.

Mr. Richardson: I believe that purely as a matter of common sense and ordinary courtesy the Motion Picture Chamber of Commerce ought to take that matter up with the I. A. T. S. E. and M. P. M. O. and see what can be done. It might result in an advantageous arrangement. I believe very likely something can be done which will be very satisfactory, and I don't see where Mr. Cudmore's remarks would lead to anything but good.

Mr. Kincaid: The discussion has been worth the trip out here. We should like the co-operation of this body. We are solving one of the great problems, I believe, in co-operation of every possible agency and in bringing into this field the best that science has been able to develop. I think something might be done along the lines of co-operating with the unions. If any one has any practical suggestions we shall be glad to receive them. If this field is developed, it will develop along the lines of getting a better picture on the screen than we have had so far. I should like to take up the point which Mr. Cudmore mentioned, that the development of this field is in competition with the theater. I think this is a mistaken idea for the operator or people to get. I think this development means more than anything else that can be done to-day. Three-quarters of the pictures shown in the schools and churches are shown for special purposes that the showing in the theaters does not cover. The pictures are brought in for a purpose—educational purposes. These pictures for educational purposes could not be used in the same way in the theaters; but it develops in the minds of lots of people an appreciation of pictures and afterwards they patronize the theaters. I feel we all should go to the theater and that the development of this field should be co-operative rather than competitive.

THEORY OF MECHANICAL MINIATURES IN CINEMATOGRAPHY

By J. A. Ball

CINEMATOGRAPHY is unique in offering the possibility of apparently magnifying or diminishing the dimension called time.

By taking the pictures slowly and projecting them at normal speed, the time in which an event appears to happen is diminished. This is very easy to do and examples where the whole growth of a plant or the construction of a building appears to take place in a few moments were made years ago and are familiar to all.

The opposite effect, namely where time is to appear magnified, requiries that the taking speed be above the projecting speed and this has only been possible of late years since the development of the high speed camera.

This effect is much more than a mere novelty, for it is the only known way in which time can be magnified to the senses. In mathematics it can be assumed that the unit of time has been changed but only the high speed camera can demonstrate it. The Germans, stressing this fact, call the high speed camera a "Zeitlupe" or time magnifier. There are obvious applications of this effect in the analysis of motions such as studies of machines in operation and of projectiles leaving guns and in flight; but aside from these kinematic applications there are dynamic applications.

For example, if, in a motion picture play it is necessary to show an ocean liner at sea and particularly if the scenario calls for the blowing up of the liner, the only practical thing to do is to construct the liner in miniature. If this model is put in a harbor or bay where the surface waves are of the correct relative miniature size and if ordinary motion pictures of the model are taken the result will be disappointing. The result on the screen will look exactly like a miniature; and the trouble will be that the boat bobs around too rapidly. Now if we take pictures of the boat at many times normal speed and project at ordinary speed the bobbing of the boat is lengthened out so that it is like the rolling of a large boat and the desired illusion is obtained.

If it is desired to show a hut being crushed in by rocks falling off a cliff it is much cheaper to do it in miniature. Here again the impression of increased size can be obtained by taking the pictures with a high speed camera and thus increasing the time required for the rocks to make the descent. Thus the high speed camera enables us to have mechanical miniatures in cinematography.

Such mechanical miniatures of boats, falling rocks, automobiles falling over cliffs, etc., have been used for several years. It is the purpose of this paper to discuss the underlying principles and to formulate some rules for guidance in making and using mechanical miniatures in cinematography.

If f, m, l and t are the symbols representing the fundamental quantities, force, mass, length and time as it is in the model and if f', m', l', and t' are the corresponding quantities in the imaginary world on the screen we can write the fundamental dimensional equations:

$$f = m\frac{l}{t^2} \quad (1) \qquad\qquad f' = m'\frac{l'}{t'^2} \quad (2)$$

Let L be the ratio between lengths in the model and on the screen, F be the ratio between forces in the two cases; M the ratio between masses, and T the ratio between 'times':

$$F = \frac{f'}{f} \qquad M = \frac{m'}{m} \qquad L = \frac{l'}{l} \qquad T = \frac{t'}{t}$$

These capital letters represent ratios of magnification of the respective fundamental quantities between the screen and the model. T is the ratio of magnification of time and is equal to the ratio of the camera speed to the projector speed. (That is, if pictures are taken at three times normal speed and are then projected at normal speed there appears to be a three-times magnification of time and in this case $T = 3$). Substituting in equations (1) and (2) we get $F = M\frac{L}{T^2}$. Where the principal forces are weights, we can write $F = MG$, (G, of course, is $\frac{g'}{g}$ or the ratio of the force of gravity between model and screen) and we have $G = \frac{L}{T^2}$; or $T^2 = \frac{L}{G}$. G is ordinarily unity. Then $T^2 = L$. This means that *all linear dimensions appear to be magnified as the square of the magnification of time.* That is if the pictures have a time magnification of 3 they will appear to have a linear magnification of 9. This applies in all cases where the principal forces are weights, which means the great majority of practical cases. It applies to falling and tumbling bodies to boats, waves, spray, etc., and would appear to be a very general law.

At present, it is not really practical to make pictures with a time magnification of over ten; this means that the greatest linear magnification at present obtainable is one hundred times. Thus if it is desired to represent a 1000 foot ocean liner by a miniature, the miniature should be at least ten feet long. Or if it is desired to make a model of a volcano one mile high the model must be at least 50 feet high.

In order to use a five foot model of a mile high volcano it would be necessary to take pictures with a time magnification of 32. That would mean a camera speed of over 500 p. p. s.

If forces other than weights are involved in a mechanical miniature they should be scaled down in the same ratio as the weights and then the above rule still holds. For example, if it is desired to represent a rock falling from a cliff and breaking through the roof of a hut, then in the model, the strength of the hut should be scaled to correspond to the weights.

The stress or strain in a plank, or in fact any beam, can be shown to be proportioned to $\frac{f}{l^2}$; and where f is proportional to l^3 (volume) the stress or strain becomes proportional to l. In other words the stress or strain in a beam depends directly on the scale upon which the beam (and its load) are constructed. If the hut we are considering is built on a one-tenth scale the strain in the roof due to the falling rocks will be one-tenth of what they would be in the full size hut. If the miniature planks of the roof are made of wood they will appear to be ten times as strong as they should be. Practically this means that good sized rocks which should crash through will merely bounce off. So the miniature planks should be made not out of wood but of a material having only one-tenth the strength of wood. Cardboard or papier mache would be about right. Or, the correct effect may be obtained by using wood and giving the planks a preliminary fracture so that nine tenths of their strength is gone.

It is interesting to consider the applications of these rules when human beings appear in the scene. If motion picture of a man are made with a time magnification of three, we would expect to have the representation on the screen of the motions of a man of nine times normal stature. Now the normal stature of a man is so well established in our minds that we do not immediately in this case get the impression of the magnification of dimensions. Referring again to the equation $T^2=\frac{L}{G}$ it will be seen that if L is not to be greater than unity, then G must be less than unity, so we can say that the pictures above referred to represent either the motions of a man of nine times normal stature or else the motions of a normal sized man in a place (such as the moon) where the force of gravity is only one-ninth of what it is here. This latter alternative more nearly represents the impression that we get from such pictures.

If, in a scene taken with a high speed camera, there is nothing to give us a clue as to the real size of the objects as for example, no real man in the scene, or better yet, if the scene includes some customary object constructed in miniature such as a miniature house or automobile, then with this assistance our impression of the normal force of gravity is maintained and immediately we get the impression of the magnification of dimensions. Undoubtedly if pictures of a man taken with a time magnification of three were to be combined with pictures of other people taken at normal speed, and if

in the speed pictures the figure was one-ninth of the distance from the camera of the others, we would get a very convincing representation of a giant of nine times normal stature.

Summary

After outlining the uses of mechanical miniatures in cinematography, rules and laws governing their use are derived from the fundamental laws of dynamics and the theory of dimensions. These rules are:

(1) Where the principal forces are the weights, all linear dimensions appear to be magnified as the square of the magnification of time.

(2) Where forces other than weights are involved they should be scaled to the same proportion as the weights and then the above rule still holds.

(3) In a miniature built exactly to scale strengths of materials should be scaled down in the same measure as the dimensions.

The application of these rules in cases where human beings are in the scene is discussed and the way in which a normal man might be used as a "working model" of a giant is pointed out.

DISCUSSION

MR. RICHARDSON: There is one thing I am unable to understand; I imagine there are many others to whom the point is not clear. What is the connection between the time-magnification and linear magnification? As I understand it, you take a picture at high speed, but how does this affect linear magnification?

MR. PALMER: As far as being familiar with the making of miniatures, I have done a good deal of work in this connection, but I should like to ask this same question of some one else as it is a new idea to me.

MR. MANHEIMER: I believe this illusion can be explained first of all by the fact that our minds usually visualize heavy moving masses as moving at certain accustomed rates of speed with relation to other masses or objects which may or may not be at rest.

In photographing miniatures in motion to represent these masses in actual projection we find that on account of the small mass of the miniature or so-called featherweight construction, it is very difficult to give these miniatures a motion which would have the same rate of speed or amplitude of vibration or the same characteristic movements of the real subjects to be imitated.

Take for example a large passenger steamer in mid-ocean. Our minds are accustomed to the rate of vibration or, let us say, the rate of pitch or roll of an ocean steamer; also our minds are accustomed to the rate of speed of the tossing waves. These in reality are both comparatively low, in fact so low that it would be quite impossible to make a small model of waves move so slowly in miniature. Therefore, by photographing the miniature with a High Speed Camera and at the same time producing pretty lively waves and tossing about of the miniature ship, we can by projecting at normal rate on the screen, slow up the rate of motion to practically any degree desired to conform with our mental expectations of what this rate of motion should be. Then again the range of perspective as it appears when the picture is projected on the screen, produces the necessary magnification.

MR. RICHARDSON: To make my point more plain, let us assume an object, a man of normal size for example. He is taken at normal distance but at four or five times the normal speed. Somewhere in the process you get a magnification in proportion to the time magnification. I can't understand that.

MR. PALMER: I can understand Mr. Manheimer's explanation—that is, where the miniature has mass and moves in accordance with the laws of mechanics, but I can't understand the action of a real person in a high speed picture.

Mr. Brown: I should like to suggest to Mr. Palmer that a real person in a high speed picture is a mechanical device and might be represented by a large marionette. If a real person walks or jumps the rate of his falling through the air is assumed by the person who sees the picture to be the normal acceleration of a mass falling, and therefore if a man takes ten times as long to take a step as we are used to seeing men take, we are likely to suppose this man is a giant falling through the last half of the step in a square ratio to the distance he would have covered if normal size. It would take a giant, six hundred feet high, ten times as long to make a step as an ordinary man because he would fall under the influence of gravity.

I suggest that this paper presents enormous dramatic and theoretical possibilities, greater than any I have seen printed in the Transactions and that it be suggested to the author that it be presented to the Journal of the Franklin Institute in order that it may be presented to the philosophical societies.

Mr. Richardson: May I ask a question? If that is true, why don't we get the impression of a giant from slow speed pictures?

Mr. Brown: If you put in the picture a single house or smal, automobile and had it on a concrete walk of the same proportions you would get the effect of a giant because of the mass-time relation suggested. The natural size of man is more fixed in our minds than the rate of fall of the foot and that is why you get the effect of a man walking on the moon; we assume gravitation has lost its force. It is only a balancing of two normal impressions.

Mr. Rogers: It seems to me that some years ago, possibly eight or nine years ago, I recall a film being shown, just after the first high speed cameras came on the market, showing a double exposure of some sort with a giant, taken by slow motion pictures running after a street car and an ordinary man reduced to miniature running beside him so that one took a great many more steps than the other.

Mr. Richardson: May I suggest that Mr. Ball be invited to present a paper at our next meeting explaining the reason for these things; there are a number of us who don't understand them very clearly.

Mr. Powrie: If we take the pendulum, from which we derive our measurement of time—a pendulum swings once a second if a meter long, but if we cut the length of it in two, it will swing $\sqrt{2}$ times as fast; I think the same thing can be applied in this case because we have the movement of the mass and the ratio of its speed based on the same thing, and the pendulum gives us an explanation of this.

Mr. Richardson: I don't see the relation between the two.

Mr. Powrie: I think the matter of introducing a man into the question is an error because a man is only a part of the mechanism and should not be considered in any other sense. We have an impression all the time of a man being of normal size and stature; without comparison with some other man we could not form the idea

of a giant. We can build smaller boats and automobiles, but it is difficult to get a pigmy to take the place of a man.

MR. RICHARDSON: I get your idea, but as I understand Mr. Ball's statement there is an unalterable speed. You increase the visible size of the thing. Frankly, I had never observed this on the screen and I don't quite see the connection.

MR. PALMER: Perhaps this was cleared up in my mind better than in any other way by the illustration of the pendulum and perhaps it will help others if I say what I am going to. If you take a pendulum and cut it in two, that is make it half as long, you can bring the camera nearer and make it look like the same thing, but you can't do this with a man.

MR. RICHARDSON: Here is the thing: Do you mean to say that you set the camera 15 feet from the pendulum swinging once a second and photograph it, and then because the pendulum is cut in two you can bring the camera nearer and give the impression of magnification, making it appear the same size with relation to surrounding objects?

DR. GAGE: It seems to me that this is an excellent paper and since the author is not here we can perhaps discuss it more freely than as if he were. (Laughter) Perhaps Mr. Richardson would let me give my version.

Suppose we take a model of the ship the length of this (demonstrating) so that on the screen it occupies the full area of the screen. Now, would it roll like the Leviathan or merely bob up and down? The effect the motion picture photographers wanted was to make it appear like a big ship. They speeded up the picture to give this impression. Now when the author got this far he asked "what will happen when we take the picture of a man?" The first answer the author gave was that if you take a picture of a man a quarter of a mile away or close by or run the picture fast or slow you do not think of him as anything but the normal size of man and you must do some gymnastics to make people think he is a giant. You need some sort of measuring stick in the picture to become familiar with the intended scale of sizes in order that a man shall really appear larger than long years of experience has taught us the size to expect a man to be.

MR. MCNABB: I should like to say that the making of miniature pictures with ultra speed cameras is several years old but this is the first time I have seen formulae applied which is productive of highly satisfactory results. I think Irving Willat now a motion picture director was the first to employ an ultra speed camera for creating the illusion produced by miniatures, Mr. Ball deserves great credit for the composition of formulae applicable to every day use.

MR. PORTER: This discussion has been very interesting to me, and it has brought up the thought that all the information is not on the East Coast. It has indicated that we are going to get a good deal of help and information from our Pacific Coast Section, which is well under way, and I think we are fortunate in having Mr. Ball's paper.

Mr. Ball (Communicated in reply to discussion): The introduction of cases where human beings appear in the scene and particularly the way in which a normal man might be used as a working model of a giant was intended as a possibly interesting, but rather fanciful application of the rules previously derived; but it has apparently resulted in some confusion and diversion of attention from the fundamental dynamical law, which it was the purpose of the paper to present.

Mr. Powrie's example of the pendulum is excellent, because the law of oscillation of a pendulum $t \propto \sqrt{\frac{l}{g}}$ is indistinguishable from the law derived in this paper. (In fact, the law of the pendulum can be derived by similar considerations.)

If an interior scene were constructed in miniature, say to 1/9 scale, and if in that scene it were desired to represent a grandfather's clock with a pendulum beating seconds, which in ordinary life would mean a pendulum about one meter long, then the clock constructed to scale would have a pendulum 1/9 meter long and this pendulum would in reality make three beats per second; so it would be necessary to take motion pictures at three times normal speed in order that, when projected on the screen, the pendulum of the clock would appear to beat once per second and consequently appear to be a full meter long. This illustration should make clear the illusion of the increase of dimensions.

The analysis in this paper shows that not only the pendulum of the clock but every other moving thing in the miniature scene will undergo this illusion of increased dimensions, provided only that:

(a) The weights are the principal forces, or

(b) that where forces other than weights are involved that they are scaled to correspond with the weights.

I am pleased to learn from Mr. McNabb that Irvin Willat was the first to employ an ultra-speed camera to create an illusion in this manner.

J. A. B.

THE FILMO AUTOMATIC CINE-CAMERA AND CINE-PROJECTOR

By J. H. McNabb

THE FILMO Automatic Cine-Camera, and Cine-Projector manufactured by the Bell & Howell Company are one of the types of machines using 16 m/m film. At the Atlantic City meeting a year ago the symposium on portable projectors included several papers having to do with machines using this film, and as the transactions since published contain a transcript and discussion of the papers, including reference to the uses and potential market for apparatus of this kind no attempt will be made to enlarge upon this phase of the 16 m/m equipment, but only a brief description of some of the important mechanical features of the FILMO instruments will be touched upon.

Filmo Automatic Cine-Camera

The camera, although of all metal construction, weighs but four and one half pounds. In operation it is held much like a binocular, the view finder being held to the eye, giving an upright position of

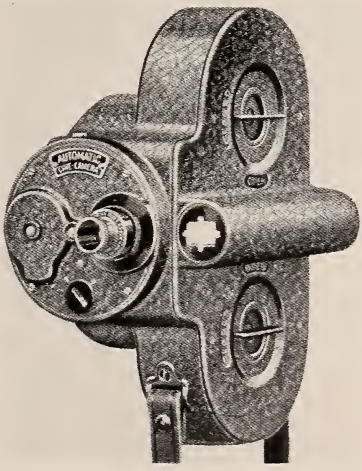


Fig. 1. FILMO Automatic Cine Camera Front.

the field, with resultant pictures as the eye sees. The movement is actuated by a self contained spring motor, housed in the main frame.

No tripod is required but provision is made for the use of one if desired. Contrary to universal oldtime beliefs relative to unsteadiness of the picture made with hand held cameras, the results upon the screen with this camera are remarkably steady, in fact much steadier than that obtained even with crank turning cameras, operated on

Fig. 2. Finder Side of Camera—Showing Holding Position.

heavy tripods. The motor is adjustead to permit of running through any desired film footage per winding, usually from twenty-five to thirty-five feet (equivalent to sixty-two to eighty-eight standard picture feet). As fifteen picture feet more than cover the average scene, it will be noted that ample capacity is anticipated for almost every emergency. The minimum usable shaft torque power of the spring ($3\frac{3}{4}$ lb.) is made applicable throughout the entire run, that is, there is no perceptible variation between the pictures exposed at the

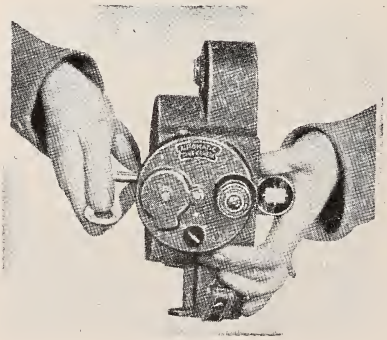


Fig. 3. Winding Position.

instant of starting and those exposed at the end of the run; the speed, however, is variable and is usually set for normal, but also graduated for half speed; a governor is employed to absorb the excess power at top winding and to effect uniform correct speed and motion. Speeds less than half and several times normal may be obtained by special adjustment of the camera at the factory.

The lens furnished as standard equipment is a Cooke Anastigmat, made by Taylor, Taylor and Hobson—England, 25 m/m focal length, working speed—F 3.5., mounted on the camera for universal focus. Other lenses such as the Carl Zeiss, Bausch & Lomb, Goertz, Astro, Dallmeyer, in any focal length, with or without focusing mounts are supplied on special order. In adopting the system of universal focusing for the lens supplied as standard, consideration was given to eliminating all operations possible for the amateur.

The film movement mechanism is of the shuttle type similar to that employed in the standard Bell & Howell Professional Camera, excepting no pilot pin registration is provided. The film is fed to and from the shuttle movement or aperture channel by means of two five toothed sprockets, spaced approximately one inch apart, thereby greatly minimizing the space required in housing the mechan-

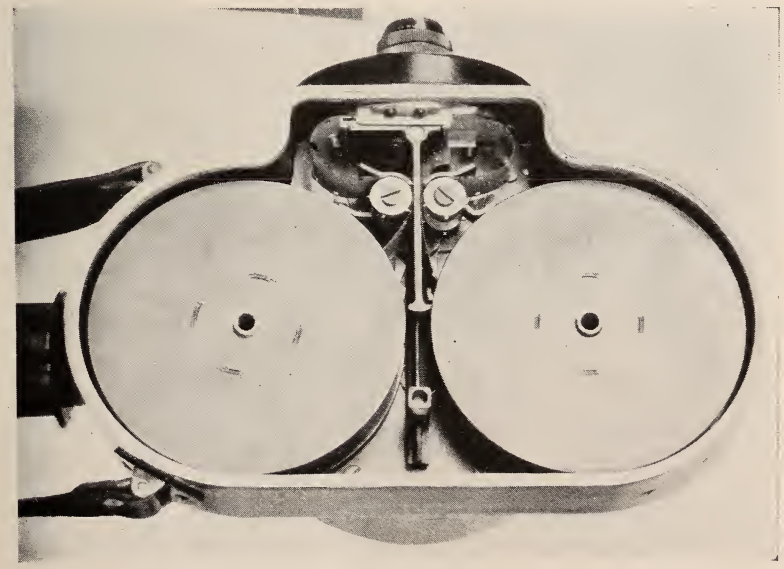


Fig. 4. Interior Showing Feed and Take-up Reels and Threading of Film.

ical units required for the feeding; taking up and loop forming of the film; threading is accomplished in about the smallest possible amount

of space without interference with a normal loop formation. The shutter has a fixed opening of 216 degrees; the takeup is of the friction type; a footage dial registers from 0 to 100 feet, which is the capacity of the camera.

Filmo Cine-Projector

The FILMO Cine-Projector is of the folding type, all metal construction, weight—9 lbs.; with case reels, film, etc.,—14½ lbs.; size when folded 6½″x9½″x10½″, capacity 400 feet of 16 m/m film, which is equivalent to one thousand picture feet of standard film. The objective lens, a Gundlach, furnished as standard equipment includes a choice of either a two or two and one half inch focal length in micrometer mounting. Other lenses stocked include 1″, 1½″, 3″,

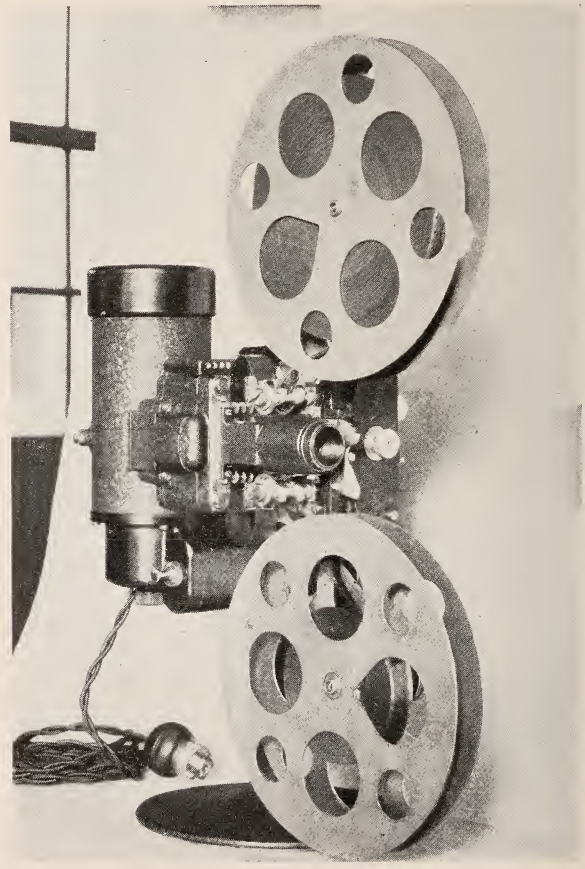


Fig. 5. FILMO Automatic Cine Projector Front.

3½″ or 4″ focal lengths, which are also provided with universal interchangeable micrometer mountings to suit the particular requirements of the user. The condensers are of the plano convex type, a double 75 m/m unit being employed as standard equipment; this permits of stopping the film on the screen without danger of warping or burning. A double 45/m/m Condenser is also supplied for users who desire to sacrifice the feature of stopping the machine for an individual frame. The light furnished with the latter condenser is approximately 25% greater than with the use of the double 75 m/m. The reflector is a spherical concave mirrored surface type, mounted with screw adjustment to obtain the maximum efficiency in focusing and intermeshing the reflected light image with the objective.

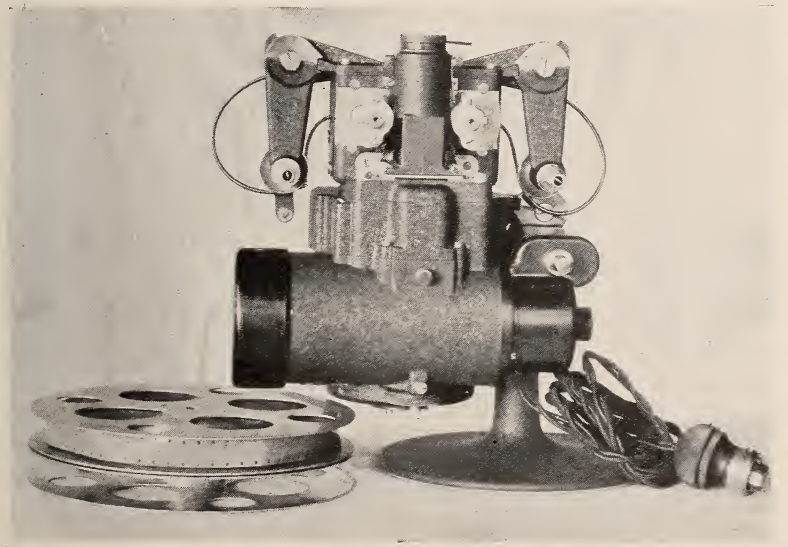


Fig. 6. Filmo Automatic Cine Projector Folded Ready for Case

The movement is of the shuttle type, the pull down taking place is 40 degrees, thereby producing a nine to one movement, a single blade shutter is employed with approximately 216 degrees opening; this shutter travels at high speed rotating three times for each pull down. A diagram of the relative time of the shutter action is appended and shows a complete analysis of the movement of the film. The motor which drives the projector is 110 volt A.C. or D.C., the housing for which forms a part of the machine. One cord is used for connection of both lamp and motor, and a switch is provided for starting both simultaneously; a cooling system supplies a forced feed air draft to the lamp house, resistance, film and aperture, allowing single frames to be projected without damage to the film.

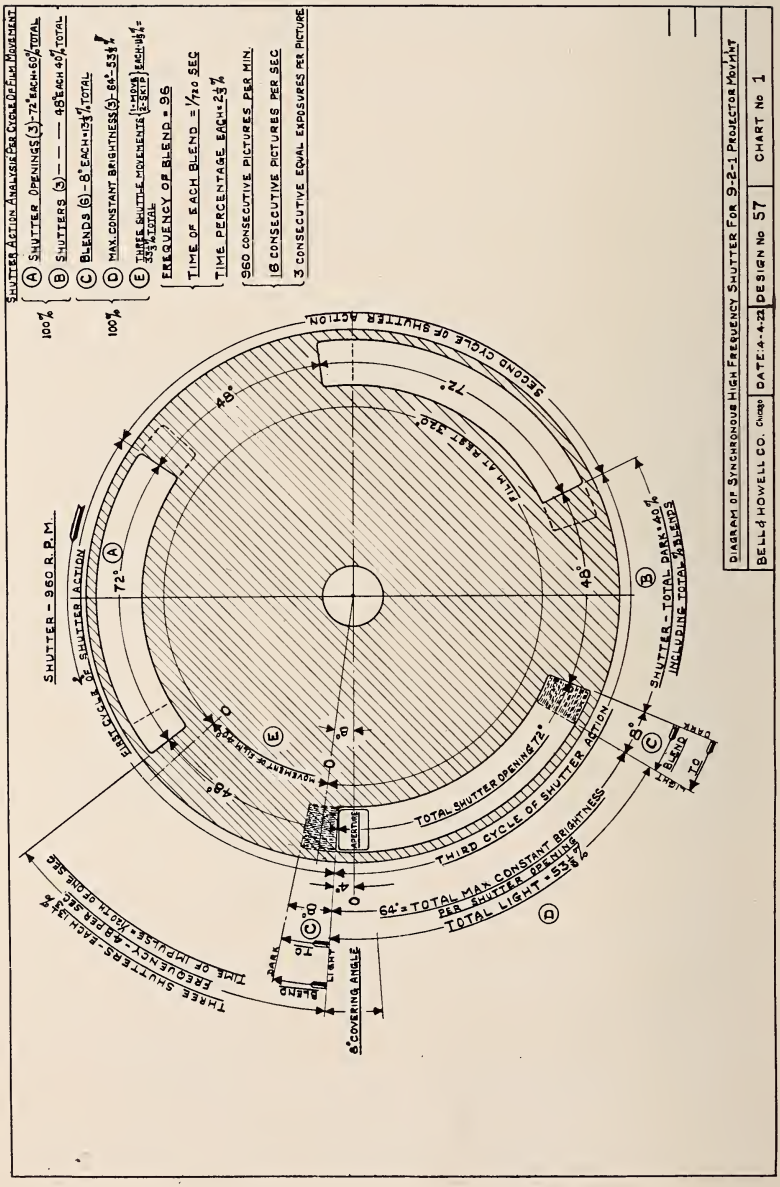

SHUTTER ACTION ANALYSIS PER CYCLE OF FILM MOVEMENT
100%
(A) SHUTTER OPENINGS (3)-72° EACH=60% TOTAL
(B) SHUTTERS (3) — — — 48° EACH 40% TOTAL
100%
(C) BLENDS (6)-8° EACH=13⅓% TOTAL
(D) MAX. CONSTANT BRIGHTNESS (3)-64°-53⅓%
(E) THREE SHUTTER MOVEMENTS (1-MOVE / 2-SKIP) EACH=11⅓% 33⅓% TOTAL
FREQUENCY OF BLEND = 96
TIME OF EACH BLEND = 1/720 SEC
TIME PERCENTAGE EACH=2⅓%
960 CONSECUTIVE PICTURES PER MIN.
18 CONSECUTIVE PICTURES PER SEC
3 CONSECUTIVE EQUAL EXPOSURES PER PICTURE
SHUTTER - 960 R.P.M.
FIRST CYCLE OF SHUTTER ACTION
SECOND CYCLE OF SHUTTER ACTION
FILM AT REST 320°
72°
48°
MOVEMENT OF FILM 40°
TOTAL SHUTTER OPENING 72°
THIRD CYCLE OF SHUTTER ACTION
64° = TOTAL MAX CONSTANT BRIGHTNESS PER SHUTTER OPENING
TOTAL LIGHT = 53⅓%
SHUTTER - TOTAL DARK = 40% INCLUDING TOTAL % BLENDS
DARK
BLEND
LIGHT
TO
APERTURE
THREE SHUTTERS - EACH 13⅓%
FREQUENCY - 48 PER SEC
TIME OF IMPULSE = 1/720 TH OF ONE SEC
8° COVERING ANGLE
DIAGRAM OF SYNCHRONOUS HIGH FREQUENCY SHUTTER FOR 9-2-1 PROJECTOR MOVMNT
BELL & HOWELL CO. CHICAGO
DATE: 4-4-22
DESIGN No 57
CHART No 1

FIG. 7

The lamp is a 200 watt, 50 volt T-10 bulb; a self centering ring is soldered to its base, for accurately centering the filament in proper position relative to the focal axis.

There is no flat tension employed at the film aperture, the control being obtained wholly by marginal contact in combination with

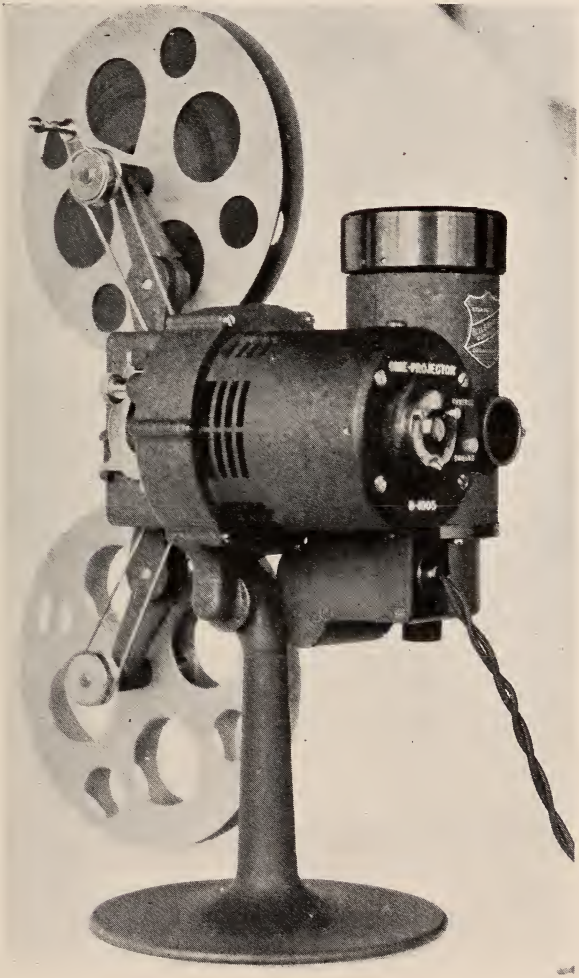


Fig. 8. FILMO Automatic Cine Projector Bear.

several rollers situated both in the aperture channel and film gate. The threading of the projector is exceptionally simple; the path of the film being in a direct vertical line, and like the camera the film is fed

to and from the shuttle movement mechanism by means of two closely situated sprockets. A small handle operating off the feed spindle permits rewinding as desired.

The resistance employed for cutting down the line current to fifty volts is unique, in that it has been possible to keep the unit down to a weight of less than 3 ounces. It is of fixed type accommodating ranges of voltage up to 115; a variable resistance is also provided for boosting the delivery to the lamp and to cut down where voltage conditions are excessive; twelve points of adjustment, ranging from forty volts to sixty-five volts is obtained, for varying the lamp current voltage.

The speed of the motor is controlled by a load brake; a clutch engages the film movement mechanism while motor is running, thereby providing a constant force of air at all times to dissipate excessive heat. If for any reason the motor should fail to function or the speed falls below normal, an automatic fire shutter working by air pressure intercepts the light from reaching the film should the machine be at the stop point or engaged in single picture projection.

A switch button controls the direction of movement, the machine will function on the reverse as readily as forward, and a change from one to the other is accomplished by shifting a lever button changing the polarity of the motor brush mechanism.

Very satisfactory pictures have been projected up to nine by seven feet, although larger sizes may be obtained by the use of the variable resistance and the double 45/45 condenser combined with an objective of appropriate focal length. This may be one inch, for extremely short distances, up to twenty-five feet, 1½ for thirty-six feet, 2 inches for fifty feet, 2½ inches for 65 feet, 3 inches for seventy-five feet, and 4 inches for one hundred feet. These lenses at the distances indicated will furnish a very satisfactory picture—size nine by seven feet.

DISCUSSION

Mr. Richardson: I don't see anything to discuss about the paper. We could discuss the demonstration, but I move that the paper be published.

Mr. Briefer: I have sublime faith in the amateur. Anything we can do to stimulate the interest of the amateur in motion picture photography will advance it materially as has been the case with still photography. This is one of the most beautiful demonstrations I have ever seen.

Mr. Cook For the benefit of any of the gentlemen interested in home entertainment with the 16 mm. film I should like to remark that the short sections Mr. McNabb showed of "The Adventurer" and "The Emigrant" are from two of the films obtainable from the Kodascope Libraries.

Mr. Egeler: I think this a good example of a projector in which real engineering has been used, where the manufacturer has not tried to follow precedent but has utilized engineering ingenuity and new features of design to gain definite objectives.

Mr. Griffin: We are supposed to know something about projecting motion pictures, and I want to say that is the finest demonstration of a home projector I have ever seen, and I think Mr. McNabb is to be congratulated. As result of that, I think he should remember all the engineers with a complete outfit at Christmas time.

A METHOD OF COMPARING THE DEFINITION OF PROJECTION LENSES

By S. C. Rogers and L. Olsen

IT IS not my intention to present a technical nor mathematical discussion of this subject but rather to present a somewhat simple and practical method by which comparatively short focal length motion picture projection lenses may be compared. For example, a motion picture theatre owner, manager or projectionist hears about some new projection lens which he may buy at a certain cost and then just as he is about to purchase it, another lens at double the cost say, is shown him. Which shall he buy? How can he determine whether or not the latter lens is worth twice as much as the first? How is one better than the other? In other words, he should have some practical means of determining under his own particular conditions, of screen, length of throw, size of picture, etc., which lens to purchase.

The performance of a motion picture projection lens is now being more fully appreciated. Exhibitors are now awakening to the importance of the reproduction of the picture upon the screen. The public is realizing that the projection of the picture it has come to see may make the picture either pleasing or displeasing; it is realizing that headaches, etc., are a result from "fuzzy-focus" and that pictures are projected upon the screen perhaps in jumping-jack fashion, at improper speed or with discolorations.

The amount of light projected upon a screen whether from one lens or another may easily be determined. Perhaps other things being equal, this may be why one lens may cost more than another. The characteristic however most noticeable to the spectator is definition or rather lack of definition or flatness of field and is manifested in a number of ways—part of the picture appears more sharply focused than the rest or the whole picture is soft or fuzzy; and it is this latter characteristic-definition—that this paper considers.

The advent of the Mazda lamp as a light source for motion picture projection is responsible to a large degree for the necessity of improving projection lenses in general. Since both the size of the light source of the Mazda lamp and the distribution of light from it are entirely different from that of the carbon arc, a new optical system had to be designed in order to obtain an efficient utilization of the light available. This resulted in a new condensing lens system which passed light through the aperture at a greater angle than heretofore thereby causing a loss of light around the then prevalent small diameter (No. 1) projection lens. If the next larger size (No. 2) pro-

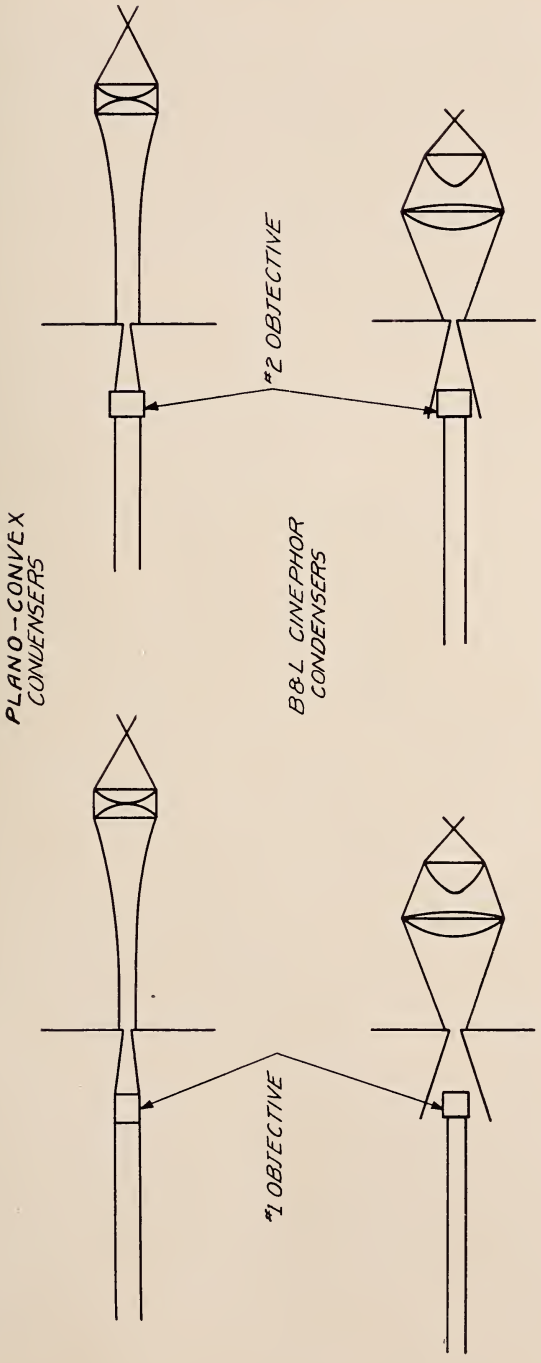

PLANO-CONVEX
CONDENSERS
#2 OBJECTIVE
B&L CINEPHOR
CONDENSERS
#1 OBJECTIVE

Fig. 1

jection lens was used, approximately double the screen illumination was obtained. These lenses however, at first were found to give poor definition when used with Mazda lamps since the whole aperture of the lens was being used whereas when the same lenses were used with carbon arc optical systems they proved satisfactory due to the fact that the whole aperture of the projection lenses was not filled with light. (Fig. 1)

This condition was serious and was remedied by the lens manufacturers by redesign of their projection lenses.

Projection lenses then should be free from

(1) Spherical Aberration
(2) Chromatic Aberration
(3) Coma Aberration

Terms used in describing the performance of a projection lens in regard to quality are vague and meaningless to the ordinary person. It is a simple matter possibly to project motion pictures upon the screen and glance at the definition but the movement of the motion picture precludes its use, necessitating therefore some sort of a stationary picture, or slide, etc., together with auxiliary apparatus so that the results may be carefully studied, repeated, checked, duplicated, photographed, charted, measured or otherwise obtained, as the case may be.

In the course of this investigation a great many negative results were obtained—in fact, most everything tried was negative.

Photographic means of recording results were attempted and were discarded—first, when a camera was used, errors of definition of the camera lens also entered into the results—second, when direct exposure was made on sensitized paper, results were obtained at times absolutely the reverse from those obtained visually due possibly to the paper being sensitive to light rays that the eye was not.

Small lenses of various curvature placed at the aperture to correct for focus, proved possible, but due to inaccuracies of the lenses themselves, and other mechanical difficulties this method was likewise abandoned.

It was quite evident then that a metal slide might prove of value in making this investigation. Many types of plates or slides were made, different size of holes were drilled in them and the number and arrangement of holes varied. Results showed that there was no trouble from heating, no cracking, nor warping but that the edges of the holes unless very accurately countersunk (which was practically impossible due to the small size of holes) caused a blurring on the edges which however was not so serious as was the fact that it was very tiring to the eyes of the observers.

Mica, lightly silver-plated and then ruled with fine lines was also tried out but although it did not crack and showed up fairly well, nevertheless, had to be discarded on account of buckling, non-uniform ruling and the small amount of light transmitted to the screen. Needle scratches on mica let though enough light but it was found that

dark lines on a white back ground did not show up as well as white lines on a dark back ground.

Diamond scratches on glass or ink lines on glass could not be used on account of the cracking of the plates unless a silvered condenser was used, which allowed only a very small amount of light to fall upon the screen. Silvered glass with needle lines scratched upon it was also unsatisfactory for the same reasons and in addition was hard on the eyes causing a peculiar flashing and glaring effect when looked at for any length of time. Many other tests were made with the conclusion from all of them that the slide must withstand high temperature and at the same time give a bright image on the screen and that the image must be such that "persistence of vision" shall not occur, and dancing images and other optical illusions must be absent.

By a combination of two of these test plates, a satisfactory means of determining the definition or flatness of field of projection lenses was obtained. A combination of a drilled brass plate and a ruled silvered glass slide appeared to answer the purpose (Fig. 2). The

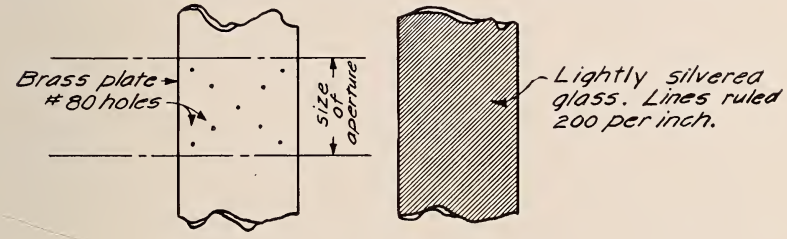


FIG. 2

ruled silvered glass slide was placed between the aperture plate and the brass plate (Fig. 3) the latter served both to protect the glass plates and to limit the light passing through the projection lens to the central and border regions. The ruled silvered glass slide further limited the light to those rays which passed through the scratched lines on its silvered surface. The image upon the screen therefore when focused by the projection lens consisted of as many spots of closely spaced bright lines as there were holes in the brass plate. Since these spots were spaced far apart, the lines did not "flash," persist or become blurred from continued observation.

Fig. 4 shows the method used in making these tests—First, the central hole was focused as sharply as possible on the screen and the micrometer moved until a click in the phones showed that contact was made. Reading of the micrometer was then made. Several readings were taken with various observers both at the screen and at the micrometer. Second, the same methods were applied to the

four corner holes in turn and their readings averaged. The difference between the center and corner readings gave a refocusing displacement showing a measure of the departure of the projection lens from complete flatness of field under these operating conditions.

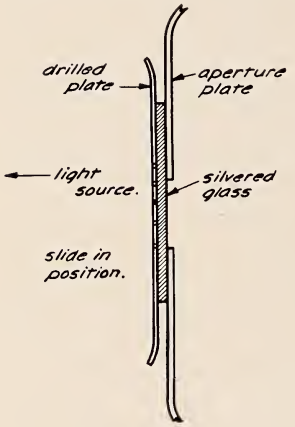


FIG. 3

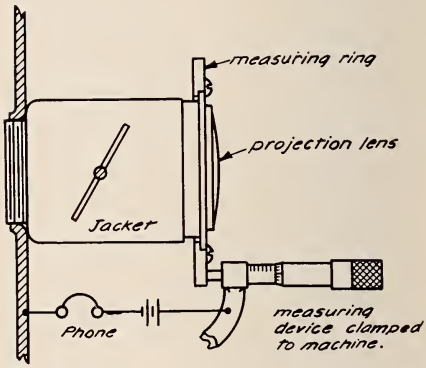


FIG. 4

49-49R

What is commercially desired is a lens in which all the lines in all the spots shall be equally sharp. A projection lens that requires no refocusing or one having no refocusing displacement for any two spots will be 100%. The amount of displacement measured in inches with a micrometer then will serve as a measure of its definition.

DISCUSSION

Dr. Kellner: I doubt whether, for lack of time, I shall be able to discuss all the points in Mr. Roger's paper that are not clear to me. It seems to me that the terms spherical aberration and flatness of field are used synonymously which, according to the physicists terminology is not correct and will cause confusion. Mr. Rogers, as far as I can see, compares the flatness of field of lenses by setting for the sharpest image on the screen, first for the center of the image, and then for the margin. The amount of difference in the location of the lens which is necessary to produce the sharpest possible image on the screen is used as a measure for flatness of field. A test for spherical aberration should give a comparison between the sharpness of the images produced by two competing lenses in the center of the field. For this purpose the means suggested do not seem to be sufficient.

Mr. Rogers: It is a test for flatness of field and sharpness on the screen.

Mr. Richardson: This is designed, as I understand it, as a tool with which the projectionist can test the lenses he has. Is it available?

Mr. Rogers: That can be constructed by any projectionist in his own projection room. It gives a comparative method of telling whether one lens gives a flatter field than the other.

Mr. Little: Is there any method of standardizing the results so that we will all talk the same language if we all make the test?

Mr. Rogers: Comparisons can be measured in terms of resetting displacement. We tried this with a dozen observers and all check the same point.

Mr. Little: I mean standardize for pattern.

Mr. Rogers: This has not been done.

Mr. Little: Can't we do it here?

Dr. Kellner: I do not believe this to be possible because the standardization of a pattern alone would not lead to results that are expressible in figures, at least not, when spherical aberration in the correct meaning of the word is under discussion.

Mr. Davidson: Does Mr. Rogers mean that the ordinary projectionist in the booth could rule a plate accurately enough and make the tests accurately enough with a micrometer to get satisfactory results, or would these plates have to be furnished to him?

Mr. Briefer: It seems that we have been talking around the subject. It involves more than merely flatness of field. I think we should accept the paper as it is and wait for another

paper on the same subject and after that, standardize the system. I do not think you can separate flatness of field from spherical aberration in the case under discussion.

Mr. Rogers: With regard to what Mr. Davidson said about the ordinary projectionist. I think for his own particular information as to whether or not one lens is better than another he could make an apparatus satisfactory to himself. Whether the results could be duplicated in another spot in the country I don't think they could, but the same comparative relation would hold. I might say that the testing was done primarily for the flatness of field on the screen itself. Whether or not one lens is twice as good for definition as another lens is the reason for rigging up this device.

RESULTS OBTAINED WITH THE RELAY CONDENSING SYSTEM

By Hermann Kellner

THE following is a brief account of results obtained with relay condensing systems in practical use. For the principles involved I have to refer to the paper given on the same subject at the Ottawa meeting.

We have fitted two Simplex machines in the screening room of the Eastman Theatre with relay condensers. They worked in every way to the greatest satisfaction of the users. The superiority in evenness of screen illumination and the lack of sensitiveness to adjustment are undeniable. Their performance is in every way in accordance with the statements made in the above mentioned paper.

The greatest success, however, lies in the application of such a system to the high intensity carbon arc. This is proved to our satisfaction by the performance of the projectors in the large auditorium of the Eastman Theatre (160 feet throw) which for several months have been working with relay condensing systems. The fact that the blueish white gas ball is surrounded by the reddish rim (shell) of the crater makes this light source rather difficult to keep in adjustment with a condenser of the ordinary type, because any unsteadiness or side-shift of the light source will cause directly an unevenly illuminated and colored field. At best, when everything is centered and in best working position the screen is illuminated by the blueish light from the gas ball which seems so objectionable to some that even colored lenses are advocated as we heard in the discussion of Dr. Gage's paper.

The relay condensing system is the radical remedy because all the light that falls on lens C_2 (Fig. 5 of the Ottawa paper) no matter from what part of the light source it comes or what its color may be is distributed all over the aperture. With the ordinary condenser we have to be careful to exclude from the aperture the marginal parts of the image of the light source because of the reddish color of the shell. With the relay condenser we welcome this reddish circle because by mixing it with the blue light from the gas ball and we gain a more pleasant approximation to a white screen. The utilization of this red light serves in a simple manner and more efficiently the same purpose as the colored lens which was proposed here yesterday. More efficiently, because the red light is added to the blueish light from the gas ball, while a colored lens would work by subtraction i. e., by absorbing some of the blue light.

If the crater should get out of alignment, the screen would still be evenly illuminated even if a part of the image of the shell should fall outside of collective lens C_2. All that could happen would be that the screen in its entire area would look a little more blueish.

In this lack of sensitiveness to adjustment and the utilization of the light from the shell lies also the great advantage of the relay condenser over the reflector. The reflector acts just like the older condenser except that it is still more sensitive to arc adjustment. By virtue of its greater light gathering power the reflector will deliver more light to the screen but it will not stand the comparison in evenness and steadiness of illumination.

Scientific Bureau.
Bausch & Lomb Optical Company
Rochester, N. Y.

DISCUSSION

Mr. Bassett: The most interesting thing in this very important contribution is the fact that it makes it possible for the first time to mix the source of light so that you get an image of the mixed light rather than an image of the source. This will make available further steps in the application of high intensity arcs. It should be possible with such a system to use 50 amp. high intensity arcs successfully in projection work.

Mr. Townsend: Since I am in charge of the projection apparatus at the Eastman Theater, Rochester, New York, I think it only right for me to say that I believe that the relay condenser system will make the high intensity arc successful. Previous to the installation of the relay system I experienced difficulty in maintaining a uniform screen illumination with the high intensity arcs, now, however, these troubles are completely eliminated. There is no possibility of getting anything but a pure, white field with the same intensity at the corners as in the center. While actual photometric measurements have not as yet been made, I feel that when they are they will show this uniformity and as Dr. Kellner remarked the difference in color of the light is very noticeable. Where we used to have an objectionable blue tone when using the high intensity arcs, we now have a screen that is really white.

Mr. Griffin: Dr. Kellner certainly said a lot in a few words. We have not had much experience with the relay condenser but such as we have had was enough to convince me that you can take all the color which was previously seen in streaks, particularly with the Mazda, out of the light that reaches the screen. There is not a vestage of unevenness in the light projected.

Mr. Briefer: There is always a high spot at every session. Dr. Kellner is to be congratulated for this valuable contribution to projection efficiency. First collecting, and then relaying the full value of the arc is a neat application of the science of optics.

Mr. Egeler: Does it require redesign of the optical system? I should like to know also whether it involves a change in the diameter of the principal condensing lenses.

Dr. Kellner: No it does not.

Mr. Richardson: I have just had brought to my attention a condenser with which I suppose Dr. Gage is acquainted. Although nothing extra in optical quality, it is guaranteed absolutely against breakage. This will allow us to decrease the crater distance from excess of which we have been suffering in the past. This new lens is

important in another direction. I think we will have some very interesting data on this by the time of the next meeting.

Dr. Kellner: The general arrangement of the optical systems at present in use does not have to be changed. The same system will work in connection with the relay system but it may be necessary to change the distance between the first condenser and the aperture plate, which is easy.

The reflector cannot be used in combination with a relay arrangement. In the relay condensing system, as we remember, an image of the first condenser is projected upon the aperture. The surface of this condenser is evenly illuminated and hence the illumination of the screen is even. This would not be so if a reflector were used because the shadows of the carbons and carbon holders would appear in the aperture and therefore on the screen.

Regarding breakage: We have had no bad experiences with the lens near the aperture nor with the one which receives the image of the light source. These lenses are made of the same heat resisting glass which we are using in Cinephor Condensers. Some of the heat resisting glass which is on the market has to be judged with lenience as to its optical qualities because it is rather deeply colored and full of striae. The chief purpose of a condenser is, after all, to transmit light and this should not be forgotten entirely in attempts to make it unbreakable.

"IS THE CONTINUOUS PROJECTOR COMMERCIALLY PRACTICAL?"

By Lester Bowen and Herbert Griffin

THE title of the paper which I am about to read—"Is the Continuous Projector commercially practical?" was suggested to Mr. Bowen and myself by the extremely large number of inquiries we have received and the great number of statements which have been made during the last few years regarding the practical possibilities of a continuous projector.

Mr. Bowen and I have been rather fortunate in that we have had a fair amount of practical experience in connection with the continuous projector developments as we have had models of apparatus of this type in our factory for test and have seen tests conducted outside of our factory, which have led us to the conclusions embodied in this paper.

Generally speaking, the continuous projector has been regarded as any mechanism through which the film passes continuously at a varying speed depending upon the action pictured, and in which the light ray is manipulated in such a way as to render the film image stationary on the screen.

There are several ways of accomplishing this result by employing different constructions which can be classified in two groups as follows:

First: Those mechanisms employing a rocking reflector by means of which the light ray is rocked sufficiently to cause the image to be projected stationary on the screen.

Second: Those mechanisms which employ revolving lenses or prisms by means of which the light ray is bent or displaced sufficiently to render the image stationary on the screen.

The first group can be divided into two classes, the first class containing those mechanisms which employ an oscillating reflector which follows one film picture in its downward movement, the light ray rocking in synchronism with the movement of the film sufficiently to render the film image stationary on the screen, and returning rapidly to pick up the next film picture and repeat the process. The second class containing those mechanisms which employ rocking reflectors which alternately pick up the successive film pictures following them in their downward movement and by rocking the light ray in synchronism with the film movement, superimpose the images of the successive film pictures on the screen in a stationary position.

The second group can also be divided into two classes. The first class containing those mechanisms which employ revolving prismatic rings or lenses which successively at each revolution pick up the film picture following it in its downward movement, and which by bending or displacing the light ray in synchronism with the film movement, cause the image of the film picture to be projected in a stationary position on the screen, and which repeat this action for each successive picture at each revolution. The second class contains those mechanisms which employ a series of revolving prisms or lenses which alternately pick up the successive film pictures and follow them in their downward movement and which by bending or displacing the light ray in synchronism with the film movement, superimpose the film images on the screen in a stationary position.

The various types of continuous projectors have been classified in the above description in order that the action of the different mechanisms may be clearly understood and in order that certain types of mechanisms can be referred to without the necessity of lengthy description.

Illumination

If we analyze the claim that the continuous projector will transmit to the screen a greater proportion of light (assuming the same light source and the most efficient optical system in each case) than the intermittent projector, it is apparent that this claim is an exaggeration and that the continuous projector will not transmit as much light as the intermittent porjector. The truth of this statement can be readily realized if we consider that in the case of the optical projector the spot of light at the aperture must be sufficiently large to cover two film pictures in height. To do this without discoloration in the corners requires a spot approximately 2¼″ in diameter, having an area of approximately five square inches, of which area less than ¾ of one square inch is available for transmitting to the screen. This means that less than 15% of the total light at the spot can be used.

Now compare this condition with the intermittent projector having a spot approximately 1½ inches in diameter with an area of approximately 1¾ square inches, of which ¾ of one square inch is available for transmitting to the screen or approximately 43%. Deducting 40% of this which is approximately the amount of light cut by the revolving shutter, we have left approximately 25% of the total light at the spot available for transmitting to the screen, or a proportion of three to five in favor of the intermittent projector. It is doubtful if this condition can be improved in the continuous projector by distorting the spot into an oblong shape for the reason that the light loss in the optical system necessary to accomplish this would more than equal the gain in reduced spot area.

The foregoing is the condition which exists in the continuous projector before the light passes through the film aperture and does not take account of the light loss which is inevitable in the optical

system (exclusive of the projection lens) whether this system is reflectors, prisms or lenses. This loss is considerable and is not at all present in the intermittent projector.

Steadiness

Considering the continuous projector from the standpoint of steadiness of screen image as compared with the steadiness of image possible with the intermittent projector, it is apparent that the continuous projectors which are included in group one can never equal the intermittent projector in this respect. In the type of mechanism in group one the intermittent movement has simply been transferred from the film to other parts of the mechanism which are much heavier and which it is impossible to move with the same accuracy that is possible when the film is moved intermittently as it is in the intermittent projector.

The continuous projectors which are included in group two present an entirely different condition for the reason that in these mechanisms there are no oscillating or intermittently moving parts, the steadiness of the image depending entirely upon the accuracy of the lenses or prisms and the exactness with which they are mounted. Included in group two there are mechanisms employing prisms or lenses that can be manufactured commercially and which should transmit an image registering to within 1/8 of an inch on a screen at 100 feet. This is true, of course, for each individual prism only. When a series of prisms is employed it is the accuracy of mounting which determines the degree of exactness to which the successive pictures can be caused to register on the screen.

The mounting of a series of prisms with the precision necessary to make the continuous projector practical will be found to be a very difficult problem and one which can only be accomplished optically. It is not reasonable to believe that a mechanical adjustment can be made which would be accurate enough for this purpose. It is plain to anyone familiar with these problems that a projector of this kind would be very costly to manufacture and that by using the most accurate prism mounting possible, it would not be possible to exceed the accuracy of registration which is easily secured with the intermittent projector as manufactured at present.

Definition

The continuous projector can never be expected to equal the definition in screen image which can be secured with the intermittent projector for the reason that any lens, prism or reflector which is interposed either between the film and projection lens, or between the projection lens and screen, will detract from the definition of the image to a certain extent, depending upon the accuracy of the lens, prism or reflector, and upon the number of surfaces, in addition to the projection lens which the light must meet or pass through on its path to the screen.

The question of definition is and has from the first been one of the most difficult problems to overcome in the development of the continuous projector. This will always be so, for the reason that any optical elements used must be highly corrected for aberration, both chromatic and spherical, and must also provide a light path which is optically the same length at any point of the film travel.

It might be well to note here that the question of cleanliness will have a great bearing on the definition of the screen image, and in a projector employing a great number of optical elements having exposed glass surfaces which must be kept clean, this is a very serious problem. A mechanism of this kind would produce a very poor picture if not at all times kept in a perfectly clean condition. This is also true of mechanisms employing surface reflectors which are very hard to keep in condition and which can very easily be seriously damaged if not properly cleaned.

Quietness

There can be no question regarding the quietness in operation of the continuous projector if constructed as those mechanisms referred to in group two, for in this type of mechanism every part is operated with a rotary motion making possible a high speed of movement without vibration or any of the objectionable noises which are noticeable in intermittent projectors.

The mechanisms referred to in group one, however, are an entirely different matter, for this type of mechanism employs rocking or oscillating parts which cause vibration, and are subject to the same objections as the intermittent projector in this respect, and this vibration also very noticeably affects the definition of the film picture.

Film Economy

One of the principal reasons for the efforts which are being made to perfect the continuous projector is the great saving in film which is possible with this type of projector. It is evident that if the film can be run continuously through the projector without the strain of the intermittent movement, that the life of the film will be greatly increased. This saving, however, is not as great as has been claimed, for the reason that a large part of the film damage is now caused in rewinding and not in the projector.

Film Aperture

In the continuous projector it has been found very difficult to provide a film aperture which will mask the picture top and bottom. There have been several different attempts made to construct an aperture which will mask the picture satisfactorily, but it has not been found possible without a great loss in illumination on the screen. The effect of the absence of an aperture is to cause the picture to appear on the screen together with a part of each adjoining picture

above and below. A condition of this kind would, of course, be strongly objected to in a theatre. This effect has to a certain extent been overcome by setting up a mask in front of the projector. This, however, is unsatisfactory, for the reason that the mask is not in focus and, therefore, cannot mask the picture sharply. The mask will either extend inside the picture thereby damaging the definition, or will allow the picture to extend beyond the frame line.

It may be of interest to briefly outline the qualities which the continuous projector should possess to make it commercially practical.

All parts should have a rotary motion.

The optical system (no matter of what design) should be a single cycle system. By this it is meant that the same optical elements should be employed in projecting each successive picture.

The light path should be optically the same length from film to screen at every point of film travel.

The optical elements used should be sufficiently corrected as to project a picture free from noticeable distortion or color fringe.

A film aperture should be provided which will sharply mask the picture on all sides.

The projector should transmit to the screen at least as much light as the intermittent projector, using a light source of the same value.

It is not our intention to be dogmatic regarding the possibilities of a practical continuous projector, and I take it for granted there will be a continuous supply of continuous projectors submitted and that a continuous amount of capital will flow into the coffers of those seeking to develop such a piece of apparatus, but we do not think that the manufacturers of the intermittent type of projector will be compelled to scrap their patents and equipment for some time to come.

Mr. Bowen will be very glad indeed to answer any inquiries or make explanations regarding the subject matter of this paper. I thank you.

DISCUSSION

MR. RICHARDSON: Mr. Bowen has omitted to mention that there is an added pleasingness to the view of the nonintermittent picture; also, there are a number of effects that can be got through slow projections, which are very unique and are not duplicated by the high speed camera. Aside from that I think the paper summarizes the matter correctly.

MR. ROEBUCK: I should like to supplement what Mr. Richardson has said about the effects obtained with slow projection.

MR. VINTEN: I do not think this machine has the advantage that the high speed camera has in the analysis of motion. I saw several machines in England, and the impression I got of four pictures a second is certainly unique in a way but does not give you the value of selection.

MR. RICHARDSON: Would it be in order to ask Mr. Vinten if the German projector is a practical thing?

MR. VINTEN: I can only give you my personal opinion. It has been in the country (England) about six months and has been tried in theatres for about six weeks. It was useful in demonstrating a color process but has a large disadvantage as the price is about five hundred pounds.

MR. BOWEN: It seems that all the first part of the discussion is in on one subject, that of slow motion, and of course slow motion can be got with the continuous projector but it is not practical because if you project under theater conditions and have high temperature at the aperture the film must be protected from this. You can't project slow enough to get the slow motion. You can get slow speed if you protect the film but not the same effect as a picture from a high speed camera will give. The action is slower and a much finer analysis of motion can be produced on the high speed camera than can be secured by projecting at slow speed with continuous projectors. The pictures you have which are taken with the standard speed camera are taken at a relatively slow speed and when superimposed on the screen, even if dissolved one into the other with the continuous projector, give only those steps in the action between the frames. Each frame is a still picture and the action between pictures is missing. When projecting at slow speed this missing action is easily seen making the steps between pictures very noticeable. There is small enough motion between the frames to deceive your eye when the pictures are projected at the taking speed.

THE STANDARDIZATION OF FILM, CAMERA AND PROJECTOR DIMENSIONS

By W. C. Vinten

TO ANY industry the standardization of its products is important, but to an industry dependent on scientific accuracy, the standardization of the vital points which govern its efficient working is most essential. It is almost inconceivable that after so many years of existence, involving the expenditure and use of such colossal sums of money, no definite standard has been universally adopted in the film industry.

From a condition of chaos in the first days a process of drift and gradual alteration has brought film dimensions somewhat into agreement. Much time has elapsed during the evolution of the sizes now generally used, and during this time, much money has been thrown away and much trouble and annoyance have been caused by this haphazard treatment.

Film is a commodity of world-wide interchange: it must pass through machines of diverse types and under varying conditions in which the discrepancies in width, pitch, size of perforation, etc., admit of but small limits. Should the variation exceed the allowable limits, speedy destruction takes place and loss is the inevitable result. Unless a standard series of film measurements be universally agreed to, it is impossible to produce satisfactory machines.

It is therefore advisable that a standard for the dimensions of perforated film should be adopted by the whole world.

There can be little doubt that the average dimensions now in general use took their start from the sizes originally adopted by Edison for the film for the Kinetoscope. A progress of gradual alteration has somewhat shortened the pitch, and the size and shape of the perforations have been repeatedly altered: so also has the distance apart of the perforations measured across the film. At the present time the average pitch for 64 holes is about 3/32 of an inch shorter than that of the original Edison, the size of the perforation is somewhat larger, and the distance apart of the perforations across the film somewhat greater.

Realizing the importance of the subject, and the desirability of settling once for all, a standard, the Kine Manufacturers' Association on December 17, 1919, held a meeting and appointed a Committee to deal with the subject. After many meetings and much deliberation, this Committee arrived at certain conclusions, and issued an interim report in September 1920. Unfortunately, it did not meet with immediate sympathy from those whom it was

intended to benefit. The principal effect of the issue of the report was a certain amount of destructive criticism in that country, an issue of a standard by a (German?) organization, differing somewhat from the Committee's suggested dimensions, another standard from the Society of Motion Picture Engineers (America), and finally the issue of positive film having larger and differently shaped holes from the average of these previously in use.

The Committee, in order to justify its findings, asks attention to the following résumé, in which is set forth its method of procedure and the reasons for its decisions.

Celluloid is an unstable substance, its dimensions are affected by temperature, humidity and age. It is coated with gelatine, another variable substance, which is perhaps quite as much to blame for alteration in size as is the celluloid itself. The Committee, having to settle definite measurements in a more or less indefinite material, took special care to allow as much latitude in all measurements as in their opinion was consistent with accurate and efficient working—whether in taking pictures, printing positives, or projecting.

The first and foremost wish of the Committee was to introduce measurements which by very nearly conforming to the average sizes in present use, should give as little trouble as could be to those engaged in the trade during the change to the new standard. The width of the original film ($1\frac{3}{8}$ in.) had for the most part been adhered to by British manufacturers for a long time after the start, but most of the Continental firms had adopted the width of 35 m. m. These two sizes have been the cause of many disputes and the loss of much time and money to the whole trade. As these two sizes were in general use, and many thousands of pounds worth of film existed on each size, it was decided to retain the two sizes, and arrange that the negative film should never be wider than 35 m. m. and that the positive should never be narrower than $1\frac{3}{8}$ in. This was considered a practical way out of a great difficulty. The discrepancy introduced by developing a wide negative thus tended to cause it, owing to shrinkage, to approximate in size to an undeveloped positive film, and to enhance the accurate and smooth passage of the two films through the printing machine. Having regard to the fact that for some time past both positive and negative stock has been usually cut to a width of 35 m. m. the Committee, after due consideration, adopted the following measurements:

Width of film $35^{mm}, +0^{mm}, -0.074^{mm}$
Gate Width 1.38 in. $(35{,}052^{mm}) -0, +0.003$ in. $(0.07A^{mm})$

The next important size was the pitch. After comparing all the different pitches of film—British and foreign—an average was struck taking into account the relative quantities of each special pitch likely to be already in use. In order to permit the film to be used with satisfaction on rotary printers, a different pitch for negative

and positive films was decided on, due allowance for the shrinkage due to development of the negative being made. This matter was very carefully considered, many opinions taken, and exhaustive laboratory experiments made so that correct results might be arrived at.

Then the distance across the film to the centres of the holes was approached, but this had to be considered in conjunction with the size and shape of the hole, in the first place on account of the weakening of the film by proximity of the perforation to its edge, and secondly, because of the possible encroachment upon available picture space.

Having settled these points in conformity with the foregoing considerations, and also with due regard to the average of the existing dimensions used in the trade, the shape of the perforation was discussed. The items taken into account were (1) The weakening of the film. (2) The correct running in camera, printer and projector, and (3) The recommendation of a shape easily verified in measurements, and easy to produce.

The dimensions of the film having been determined, the size of the sprockets and the shape of the teeth were merely matters of mathematical calculation plus a certain amount of practical experience in deciding the largest allowable limits compatible with efficient and accurate working. The remaining measurements recommended by the Committee were not considered of such vital importance as those governing the film, nevertheless the Committee believe that the adoption of all possible standards will save money to any firm in the first 12 months' work, even though considerable expense be incurred at the outset. In the majority of cases of alteration, the expense would be quite trivial and not to be considered by the side of the resulting saving in money, time, and the elimination of disputes.

One alteration in size was recommended by the Committee, i. e. that of the core upon which the film is sent out by the makers, and upon which it is coiled in the camera. Although this alteration might on its first introduction cause some trouble and expense, it is believed to be of such importance that it demands the earnest attention of all concerned in the industry. The Committee ask special consideration of this recommendation, the universal adoption of which they think would be of incalculable benefit to all in the trade. It is well known to all who handle film that the inside of the coil assumes an inconvenient curl which is difficult to deal with. Trouble is caused in the darkroom, in loading the camera, in the printing room, in the printing machine, in the projector and in rewinding, in fact, in every case where the film is handled. The cause of all this trouble is the strong curl which the film has acquired by being kept wound to so small a diameter. Loss of time, temper and money result every day and in every part of the world from this untoward fact. Sometimes the end of a negative, probably

containing the vital point in the conclusion of the action, is rendered unusable: and quite frequently it is necessary to make re-prints of the last section of the positive owing to the extreme liability to damage, directly due to this method of winding and packing.

The sizes of the respective masks for Camera, Printer and Projector suggested by the Committee have caused a certain amount of controversy. The reasons for these suggestions are tersely stated in the interim report. Possibly the small amount of information given has led to some want of understanding of the real gist of the matter. A further explanation is probably necessary. The size of the mask of the Printer is larger than that of the Camera mask, so that on printing the negative a black frame or border is produced round each positive picture. The size of the mask of the Projector is an intermediate between the sizes of the masks of the Printer and Camera, consequently a part of the border is projected and the original picture in the negative film is projected in its entirety.

Should there be unsteadiness due to wear of parts in the Projector, want of registration in the Printer, or defective film, the faulty result on the screen will be far less obtrusive than in the case where the picture is framed either by the image of the Projector mask or by the blacking out round the screen itself. Fixed objects near the side of the picture in the former case will always remain at a fixed distance from the frame, instead of altering their position with regard to it, as happens in the latter case. As the frame and picture are both on the film, slight unsteadiness is scarcely noticeable and even a considerable movement becomes less obtrusive.

Although the Committee looks back on its work with feelings of satisfaction, with a sense of duty honestly performed in the interest of the Industry as a whole, it is disappointed that it finds reluctance on the part of the users of apparatus to fall in with its conclusions, and an individual objection to alter any existing item however small. Since the Committee issued its first report, two new sets of standards have been suggested, one from Germany and one from America, and recently the Kodak Company has introduced a new shaped perforation in the positive stock.

The German standard differs in some respects from our conclusions, as also does the American, and they differ slightly the one from the other. They, however, so closely approximate to our sizes, that in the majority of cases little or no trouble is to be feared from their use—but why have three standards when one will suffice?

The enlarged and re-shaped hole in the positive is a greater departure from the average of the present sizes and it appears to the Committee that trouble may occur from so drastic an alteration, especially in joining to films perforated to present standards. While giving Messrs. Kodak all credit and the thanks of the trade for their investigations concerning the life of the film, and not in any way disagreeing with the result of their experiments, which in the labora-

tory conclusively proved the advantage of the alteration, the Committee would point out that practical use is the only reliable test. The production of positive film, perforated in quite a different style from that of the negative, appears to them a step in the wrong direction and one likely to cause considerable trouble in the near future.

The shape of the perforation is also a difficult one to guage correctly owing to the small radius at each corner; and the production of punches true to the required dimensions is a problem requiring engineering skill of very high excellence. The manufacture and maintenance of the punches would necessarily be costly.

But by far the greatest mechanical trouble will be found when an attempt is made to produce perfect sprocket-teeth suitable to drive the film. The method suggested by Messrs. Kodak we think quite impracticable. The difficulty of forming a tooth having involute curved surfaces with an upright piece at the base is bad enough; but the required radius at each corner, which has to follow, first the junction of two surfaces, one involute and one flat but at an angle to the other and then the straight section at the base, which base is the curved circumference of the sprocket is calculated to reduce the best mechanic to a state of bewilderment. Variation of sprocket diameter further alters the conditions. The wear of sprocket-teeth in nearly all cases is first manifested at the base of the tooth, just where the fillets or burrs occur which Messrs. Kodak suggest should be removed by means of a wire brush. The Committee thinks that this method of working would produce sprocket-teeth already in a partially worn condition.

In the drawings supplied by Messrs. Kodak, the film is shown with a section of the sprocket-tooth in the driving position. The perforation is shown with rounded corners, and the section of the tooth also with rounded corners, but of a smaller radius than that of the perforation. Several examples illustrating diverse conditions of the films are given, but in no case do the respective rounded corners touch one another, the flat parts, only, being shown in contact. Now, how is this desirable condition to be maintained? If the side movement of the film be prevented by edge guides, what is the use of that portion of the tooth lying to the right and left of the start of the curves at the corners? If no edge guides be employed, the shapes are most unsuitable, because in the case of the side of a tooth coming into contact with the side of the perforation, (a condition certain to be constantly occurring) the driving pressure would concentrate at the point of contact of two curves at which the angle of repose commences. The flat would therefore become inoperative until destruction of the critical corner had taken place.

Absolute contact of more than one pair of driving teeth being admitted, it is difficult to understand why the case of six teeth in work should be considered at all. The only real advantage possessed

by the enlarged hole seems to be the practical possible engagement of six teeth. Seeing that four teeth in possible engagement is the standard practice, the advantage is not of any account. Though the enlarged hole *may* under some unusual condition tend to prolong the life of the film, the Committee feel sure that practically, and under ordinary conditions, no good could result which might be calculated in any degree to compensate its many disadvantages. Such an alteration from existing average sizes can only be expected to result in trouble and loss.

In conclusion, the Committee feel that the whole subject can be easily and quickly unified by those most interested getting into touch with one another. The outstanding differences are in nearly all cases so small as to be almost negligible—but not quite negligible—because any difference, however small, absolutely nullifies standardization.

Seeing how important is the matter to every branch of the industry, and to all engaged in it, the Committee think it would be well, failing a more general acceptance, for America and England to agree to a definite standard, and believe that such a proceeding would bring the whole world into line—to the great and lasting benefit of all concerned.

DISCUSSION

MR. J. G. JONES: I want to point out that the corners of the teeth do not engage the fillet of the perforation as the film would not side-weave to that extent.

MR. VINTON: I believe you misunderstood this. What worried our committee was that you showed the tooth rounded and in your paper you say, "after rounding the tooth," so that we took it that you meant it to be correctly rounded.

MR. J. G. JONES: After machining the teeth of the sprocket the corners can be slightly rounded. The flank surface of the teeth should be made very smooth.

MR. VINTON: We want a definite size, which an ordinary mechanic could not get.

MR. J. G. JONES: The radius of the round corners of the teeth does not have to be exact. You can easily approximate the required amount.

MR. VINTON: Such procedure shortens the surface of contact.

MR. J. G. JONES: The small overlap of the corners of the sprocket tooth where the radii of the corners of the perforations become tangent would be so slight that with a load of 16 oz. pull on the film, the film would flex enough to offset that amount.

MR. VINTON: Do you not think it would be sufficient to cause a fracture?

MR. J. G. JONES: No, we tried it out. I should like to ask to what extent the British exhibitors have adopted the different size masks to allow a black border.

MR. VINTON: We have not been able to have this adopted except as regards the camera. For the camera it was accepted but the exhibitor has not as yet cut out the corners of the projector mask so as to produce a screen picture having sharp corners.

MR. BRIEFER: I fail to see the need for stressing the question of the overall width—whether it is exactly 35 mm. or a fraction over or under, especially in view of the variable shrinkage. The principal dimensions are those between the sprocket holes, and these are fixed by the mechanical devices in use.

I wish to warn against one thing if I may. Mr. Jones has suggested that the round corners of the sprocket tooth and the corner curves of the sprocket holes need not coincide and explains that in the case of shrunk film, the load of 16 ozs. per foot at the gate will compress the film edge and so force coincidence between the shape of sprocket tooth and perforation.

From this we are led to believe that dependence can be placed upon the flexing or bending of the perforation edge to compensate the

form of contact. In this we confront difficulties. The bearing strength of any material is directly as the cross section area. If the force at the contact point of sprocket tooth and perforation edge compresses the film, as Mr. Jones explains,—if this compression is ever so little, then the bearing strength of the film is exceeded and an early fracture must result from repeated flexures. It must be evident that the perforation edge should take the blow of the sprocket squarely and without appreciable yield.

I think the ideal perforation has not yet been devised. The mechanical difficulties are very real but if we imagine a perforation base line slightly arched and a tooth concaved to coincide with this arch, then the force of the blow would fall centrally over the base line of the perforation with the result that the supporting strength would be greatly increased.

Whatever is done, I feel sure that we should avoid any condition that tends to compress or flex the film at the contact area of sprocket and perforation edge.

Mr. J. G. Jones: I should like to emphasize one point. We are talking about something rather difficult to conceive. If you take the height of this when you are getting down to thousandths you will have to do some calculating to show what a small amount that is. Five thousandths of an inch laid out to scale as compared with the width of the film is a very small amount and the bending permitted will be only of the order of the thickness of tissue paper.

Mr. Richardson: That is quite true, but don't forget that anything which causes unsteadiness of the picture is magnified enormously when this is projected onto the screen.

Mr. Griffin: As I understand Mr. Jones now, all that is desired is to break the corner of the tooth. We understood at first that you proposed to establish a definite radius and we wondered how this could be manufactured.

Mr. J. G. Jones: If you show it slightly rounded, one man's idea of the extent of rounding will be different from another's. A rod of the proper diameter will give a good idea of what is meant.

Mr. Vinton: With regard to the width of the film, our reason for keeping a definite close limit is that the foreign machines have side registration to the gate and the width must be kept fairly close. We had trouble with one machine in which it was expected to run 35 mm. stock on a gate width of 1-3/8 inches.

IMPROVEMENTS IN MOTION PICTURE LABORATORY APPARATUS

J. I. Crabtree and C. E. Ives

Communication No. 206 from the Research Laboratory of the Eastman Kodak Company.

A DESCRIPTION of the following apparatus in use in the Film Developing Department of the Research Laboratory of the Eastman Kodak Company.

1. An Apparatus for Making Motion Picture Titles.
2. Continuous Film Viewing Machine.
3. Semi-Automatic Sensitometer.
4. Safety Devices.

1. Apparatus for Making Motion Picture Titles

When this apparatus was designed it was required to take care of title cards of varying sizes so that it was necessary to be able to vary the distance between the camera and title card holder from two to six feet. In choosing between a horizontal and vertical arrangement of camera and easel the vertical arrangement has many advantages when photographing title cards of uniform size, but in order to be able to vary the distance between the camera and title card it would be necessary to move either the camera or easel against gravity so that the horizontal arrangement was finally adopted.

A second problem in design was whether to incorporate all adjustments in the easel, the camera remaining stationary; or to construct a fixed easel and incorporate all adjustments in the camera supports, or to make both camera and easel adjustable. It was finally decided to make the easel adjustable in a vertical direction, to rotate the title card holder, and to secure side adjustments by moving the camera. In view of the difficulty of preventing vibration of the camera, it is considered that it would be preferable in future designs to secure side adjustment by moving the title card holder and not the camera.

The Camera

The camera and bed are shown in Figure 1. The camera and driving motor rest on a cast iron plate which in turn rests on a second plate (P) which in turn rests on frame (Q) fitted with tracks so that plate (P) can be moved from left to right and vice-versa by means of worm (W) which is rotated by means of a handle at the right of the camera. Plate (Q) slides along tracks which rest on beams (T) which

in turn are supported on an angle iron frame. The right hand track is fitted with a rack and pinion so that by turning handle (H) the camera may be moved towards or away from the easel.

The camera is connected to the driving motor by means of a worm and worm gear. The driving shaft is fitted with a universal

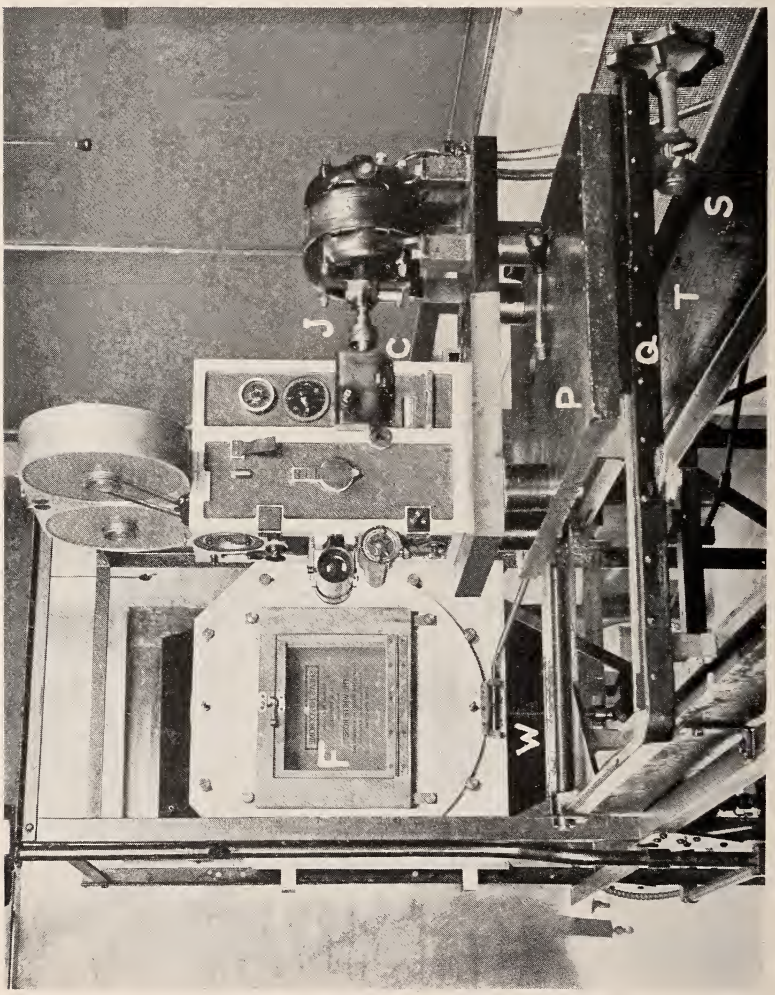


Fig. 1. Title Making Apparatus.

driving joint (J) and the left half of the shaft is pivoted so that by disengaging a retaining pin at (C) the worm is disengaged from the worm gear so that the camera can be cranked by hand. The speed of the motor is adjustable by means of a variable rheostat and the motor is reversible.

The Title Card Holder

This is shown drawn to scale in Figure 2. It consists essentially of a circular aluminum plate supported on grooved roller bearings R_1 R_2, etc.) and fitted with a rack and worm at (W) so that the plate may be rotated in a vertical plane. The worm (W) is attached by means of universal joints and a sliding member (S) so that the necessary adjustment can be made by turning a handle at the right of the camera.

ADJUSTABLE TITLE CARD HOLDER

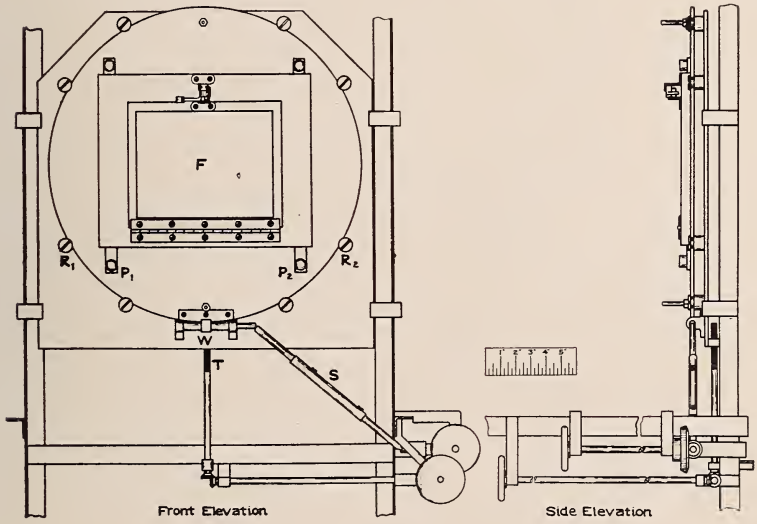


FIG. 2

Adjustment of the easel in a vertical plane is secured by sliding a second aluminum plate, to which the circular plate is attached, by means of a screw (T) which is connected by means of bevelled gears to a rod fitted to the right of the camera carriage. Both the vertical and rotating adjustments can, therefore, be made by turning handles immediately at the right of the camera.

The Title Cards

When making titles direct on to positive film, by photographing black letters on a white card either with the base side of the film facing the lens or directly on to the emulsion by using a reversing prism, it is not possible to secure as much photographic contrast as when photographing by transmitted light, that is, by photographing the printed matter on a transparent base placed against the illumi-

nator. When photographing bold type matter, satisfactory contrast can be secured by photographing with reflected light but in case hair line lettering or small font type is used the lettering invariably "fills in" if a sufficient exposure is given to secure the necessary density of the title background. In such a case transparent title cards must be used. The cards may be conveniently made by printing directly on to celluloid in a printing press and then dusting the letters while the ink is still tacky, with a good grade of carbon black and when thoroughly dry removing the excess with a soft brush or pad of velvet. Transparent title cards can also be made photographically either on plates or films but this involves more expense.

The transparent title cards are supported in a frame (F) which consists essentially of a photographic printing frame fitted with a plate glass base and a plate glass hinged pressure plate. The glass in the pressure plate is fastened in a narrow wooden frame and is buffered by means of springs so that the film is maintained as nearly flat as possible.

Transparency titles are illuminated by means of a bank of "Cooper-Hewitt" lamps placed behind the frame (F) while reflection titles are illuminated by a bank of lights placed on each side of the title card holder. The apparatus was originally fitted with a bank of nitrogen filled lamps arranged in the form of a square immediately in front of frame (F) but when photographing on positive film the photographic actinic power of such lamps is very much lower than that of mercury vapor lamps so that this method of illumination was abandoned.

When making titles by reflected light, the frame (F) is removed by inscrewing clamps (P_1P_2) and a wooden board to which the cards are pinned is then attached to the aluminum plate by means of thumb screws.

It is apparent from the above that when operating, all adjustments can be made while viewing the title image in the camera gate. In order to insure that the printed matter is parallel with the frame line, it has been found most convenient to sight across a straight edge fitted to the top of the camera. In this way strict parallelsim is insured even though the camera itself may not be level.

2. A Continuous Film Viewing Machine

This machine was constructed in order to permit of viewing the continuity of negative and positive film and for cutting out defects at the assembly table. It has been found most useful for examining negative film but for small laboratories it should prove useful for the final examination of positive film without the necessity of examination in the standard projector. In the larger laboratories a continuous projection machine would appear desirable because it would be less liable to injure the perforations at the high projection speed employed in many inspection rooms. It is impossible to project film at three or four times the normal rate of projection in an intermittent projector

without producing corner fractures or otherwise injuring the perforations unless the projector mechanism is examined at very frequent intervals. It is important that more care in projection should be taken on the part of laboratories in order to insure that the wearing qualities of the film are not impaired when it leaves the laboratory.

By means of a single sprocket the film is drawn continuously and without intermittency past an aperture plate fitted with a viewing

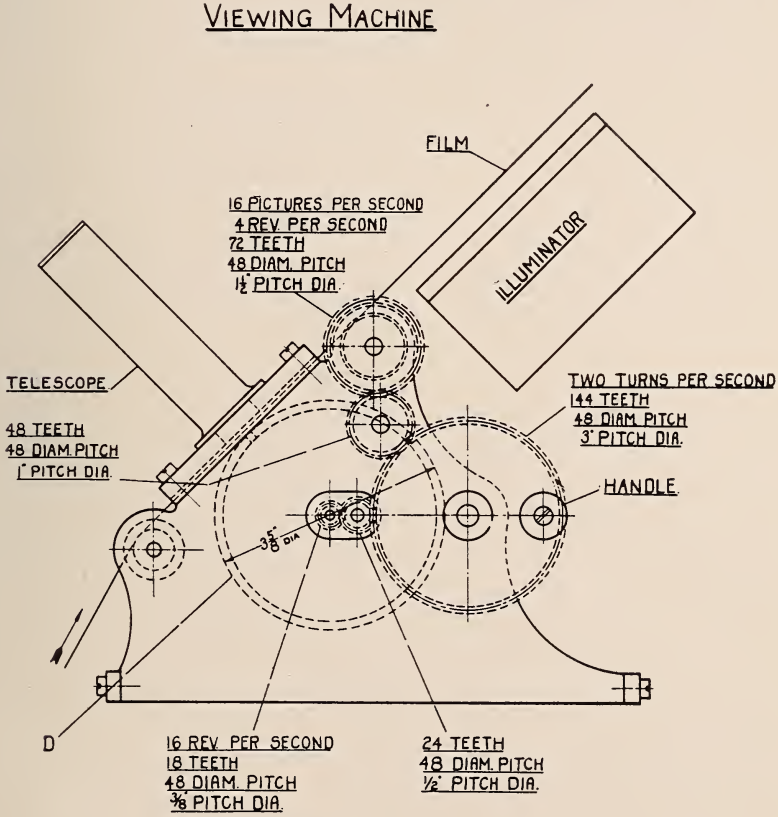


Fig. 3

eye-piece and at the point when each picture frame registers with the aperture or gate it is instantaneously illuminated so that an intermittent effect is secured. The instantaneous flash of light is produced by means of a rotating hollow drum fitted with a horizontal slot at the periphery and a 21 candle power automobile head-light bulb at the center. The hollow drum is so geared with the driving

sprocket that for every revolution of the drum the film progresses through four perforations. Two turns of the crank handle per second give 16 frames per second at the viewing aperture. More or less flicker, of course, exists depending on the rate of cranking but this is not objectionable and in no way interferes with the usefulness of the machine in following continuity or cutting out defects. Sufficient working details are given in Figures 3 and 4 to enable the machine to be constructed by any good tool-maker.

The actual machine is shown in Figure 5. The film is passed from reel (R-1) over idler (I) under the recessed gate, over driving sprocket (S), over illuminator (L) to the take-up reel (R-2). The telescope is fitted with a three-times magnifier to facilitate viewing. The gate is adjustable for framing and both gate and sprocket are recessed so as to prevent contact with the film. The illuminator (L) serves to facilitate cutting and is operated by footswitch (F) which extinguishes the drum light (B) when (L) is illuminated. For continuous service a motor drive would be preferable.

No originality is claimed for the fundamental principle of this machine which is designed on the lines of an experimental model constructed by Messrs. Newman and Sinclair, London.

3. An Improved Semi-Automatic Sensitometer

In a previous paper by Jones and Crabtree[1] an automatic sensitometer for timing negatives was described and in a later communication[2] details for constructing a simple modification of this instrument were given. This modified instrument is essentially similar to a printer box as employed by the professional photographer for making paper prints. The negative and positive are placed over a graded sensitometer tablet, over which is fitted a pressure platen. Underneath this tablet an illuminator is fitted and so arranged that on pressing the platen the tablet is illuminated, and extinguished when the platen is released. The time of exposure is determined by means of a clock.

Experience with this machine soon indicated that some method of automatically timing the exposure was necessary and of the various methods of accomplishing this, an electrical device was considered the most economical and easy to construct and this was adopted as follows:

The Timing Device

This consists essentially of a means for making and breaking the lamp circuit for definite time intervals and is effected by driving a cam with a constant speed motor, the cam in turn operating a sliding contact.

[1] "A New Sensitometer for the Determination of Exposure in Positive Printing," by L. A. Jones and J. I. Crabtree. Trans. Soc. M. P. Eng. 15, 1922, p. 89.

[2] "Development of Motion Picture Film by Reel and Tank Systems," by J. I. Crabtree. Trans. Soc. M. P. Eng. 16, 1922, p. 163.

With such a device it was found necessary to install a method of signalling which would indicate to the operator when to press and when to release the platen and this was effected as follows: Referring to figure 6, the constant speed motor drives two cams attached to a common shaft, one of the cams operating a contact breaker for the exposure lamp circuit while the other cam operates the signal lamp circuit. The signal lamp circuit cam over-laps the exposure lamp cam at both ends so that the signal lamp lights about 1 second before the exposure lamp and remains lighted until the latter is extinguished. In this way the operator is warned not to press the platen while the red signal lamp is illuminated.

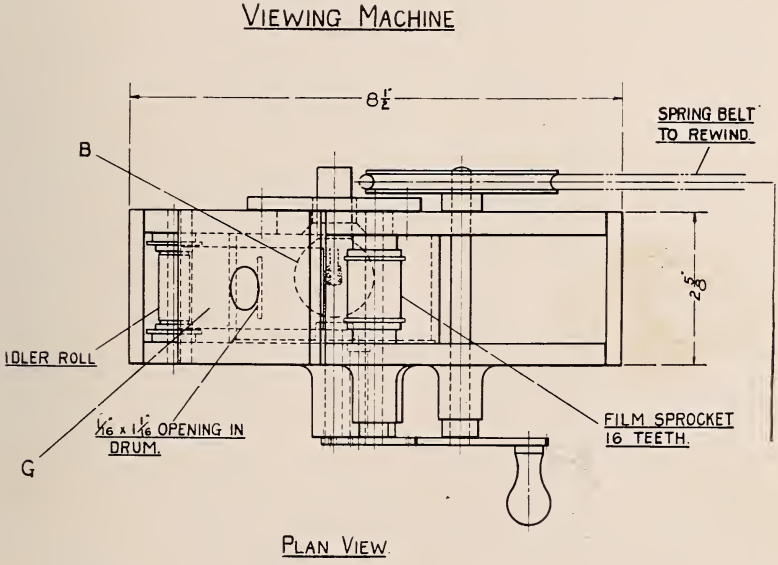


Fig. 4

The length of the exposure is determined by the angular measurement of the cam and in the instrument described this was adjusted so that a constant exposure of two seconds was given. When matching the timer with the printer the intensity of the sensitometer lamp is adjusted by means of a rheostat and volt meter.

In order to prevent an error on the part of the operator when pressing the platen a signal bell was installed which rings whenever an error is made. The mechanism of this is shown in Figures 7 and 8.

The platen when pressed operates a 3 point switch (Fig. 8). The two lower contact points are in circuit with a set relay which in turn is in circuit with the electric bell. If the platen is pressed or released when the timing device is making contact in the exposing lamp circuit, a current flows and actuates the set relay, causing the bell to

ring. Ringing of the bell, therefore, indicates that either (a) the platen was pressed or released at the wrong time or (b) that the pressure on the platen was not sufficient.

The set relay is shown in Figure 7. Whenever the bell rings the relay must be reset by pulling out the "choke" handle (C). The wiring diagram (8) is self-explanatory.

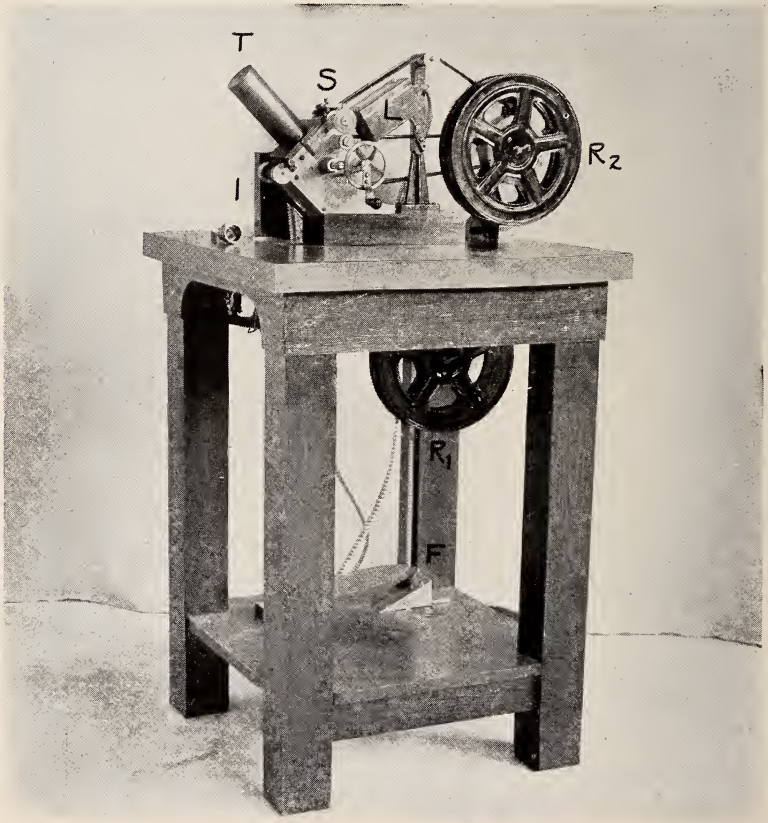


Fig. 5. Continuous Viewing Machine.

The sensitometer proper is shown in Figures 9-10-11. The sensitometer tablet is inset in the top of the central box which is fitted with a monofilament tubular lamp (L) a signal lamp (S) and a safelight (G) to the left of the tablet, each lamp working independently in a separate compartment. The safelight (G) is for the purpose of registering the frame lines of the negative with those of the tablet. The adjusting pins (A) are to assist in the registration.

The voltmeter (V) illuminated by lamp (I) indicates the lamp voltage, which in turn is controlled by rheostat (R). The "choke" (C) is for resetting the relay. The authors are indebted to Mr. A. C. Hardy formerly of this laboratory for valuable assistance in designing the timing and signalling devices.

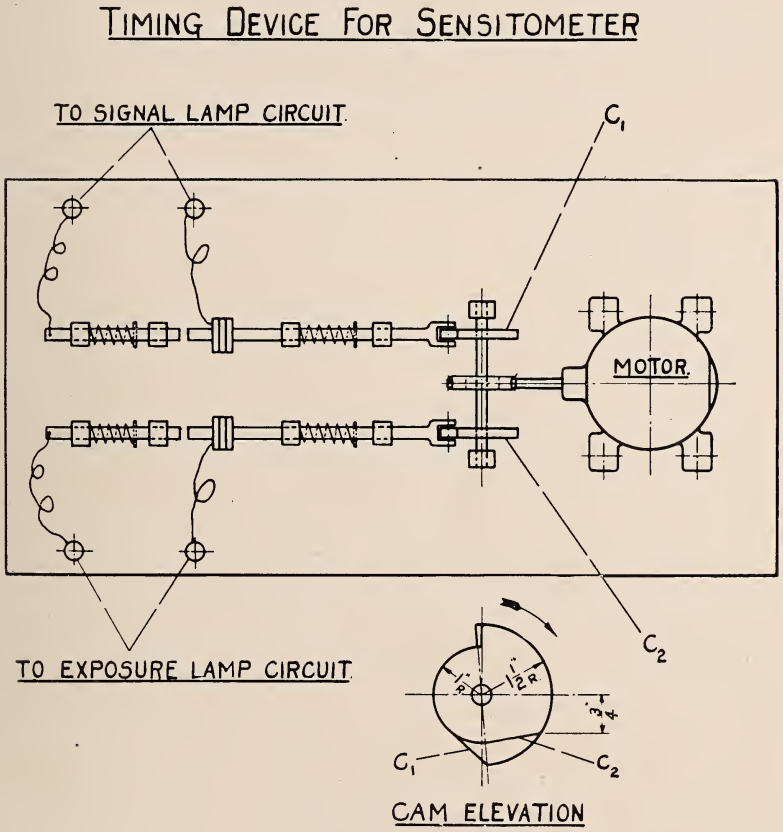


FIG. 6

4. Safety Devices

Whenever inflammable material such as cellulose nitrate film is handled, great care must be exercised to prevent any possible short circuit in the electrical system while care must also be taken that film does not come into contact with heated radiators, which should be screened, or with electric lamp bulbs. The heat from an ordinary electric bulb is sufficient to ignite a piece of nitrate film which may happen to be in contact with it for a sufficient length of time. Waste film should also be immediately placed in a metal container. With a

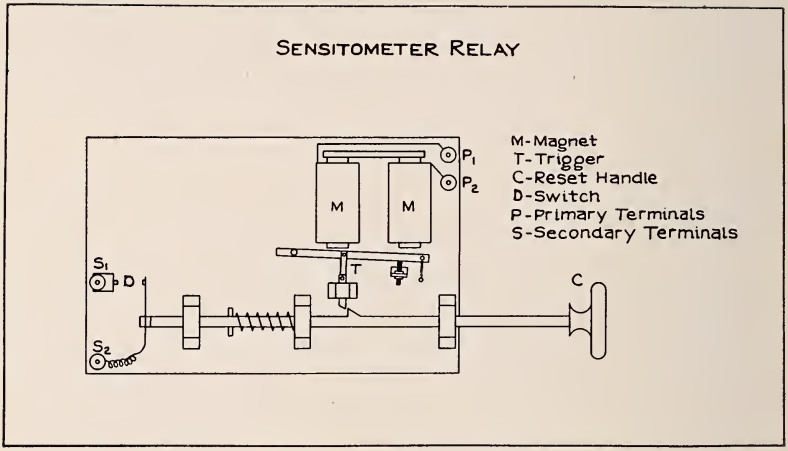

SENSITOMETER RELAY
M-Magnet
T-Trigger
C-Reset Handle
D-Switch
P-Primary Terminals
S-Secondary Terminals
M
M
P1
P2
T
C
S1
D
S2

FIG. 7

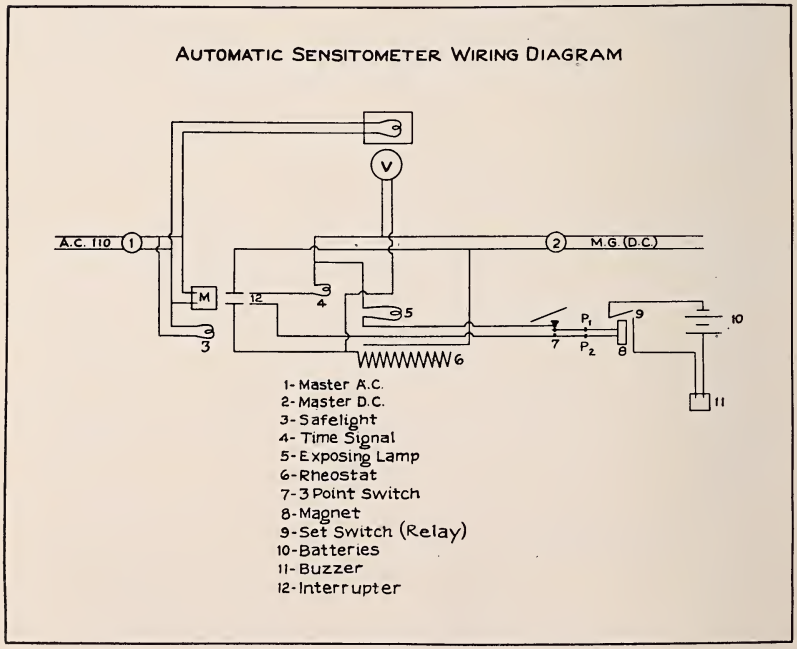

AUTOMATIC SENSITOMETER WIRING DIAGRAM
A.C. 110
M.G. (D.C.)
V
M
1-Master A.C.
2-Master D.C.
3-Safelight
4-Time Signal
5-Exposing Lamp
6-Rheostat
7-3 Point Switch
8-Magnet
9-Set Switch (Relay)
10-Batteries
11-Buzzer
12-Interrupter

FIG. 8

view to eliminating danger from the above causes the following devices have been adopted:

(*A*)—*A Safe Electrical Plug and Socket*

The ordinary screw electrical socket is apt to cause arcing if unscrewed when the electrical circuit is complete, while if the cable is strained a short circuit is apt to result from crossing of the wires. The ordinary two prong type of plug is not satisfactory because it is not possible to ground a machine with such a plug, although if any strain is placed on the cable the plug usually becomes disconnected,

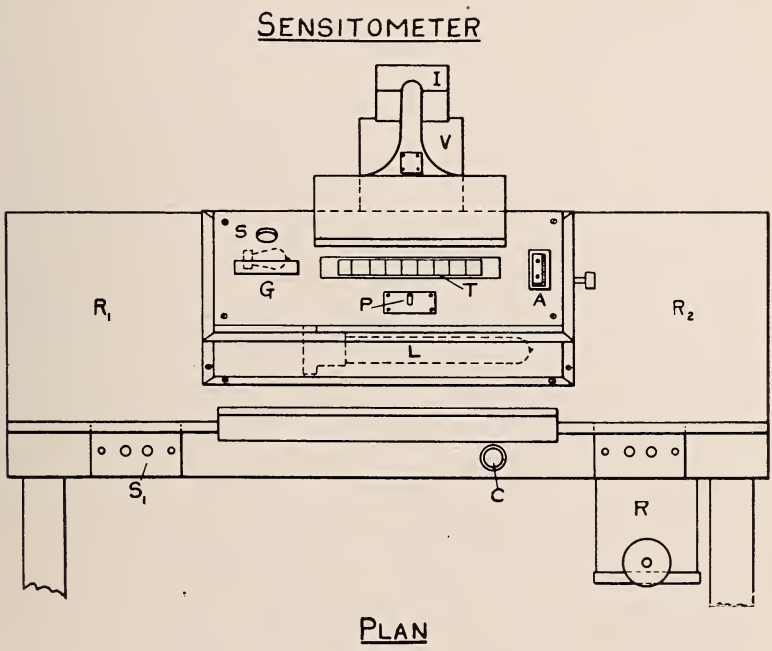


FIG 9

thus eliminating the danger of a short circuit. A satisfactory plug should not arc; it should become disconnected if the cable is strained, and it should be possible to ground a machine through the plug. A plug and socket fulfilling these conditions is shown in figures 12 and 13. It is essentially similar to the ordinary two prong plug excepting that it is of more rugged construction and is fitted with an outside metal collar which fits over a second metal collar surrounding the socket which, in turn, is in connection with the grounded conduit. In this way it is possible to ground a machine through the armored cable which is soldered to the plug.

(B)—An Inspection and Assembling Table

Many laboratory inspection tables are fitted with an illuminator which is set in an aperture in the table top but such an illuminator is dangerous because particles of film are apt to fall on the heated lamp bulb with the possibility of fire while there is also possibility of fire from short circuiting of lamp wires. A safe inspection table is shown in figure 14. The table is of steel and is covered with an opal glass

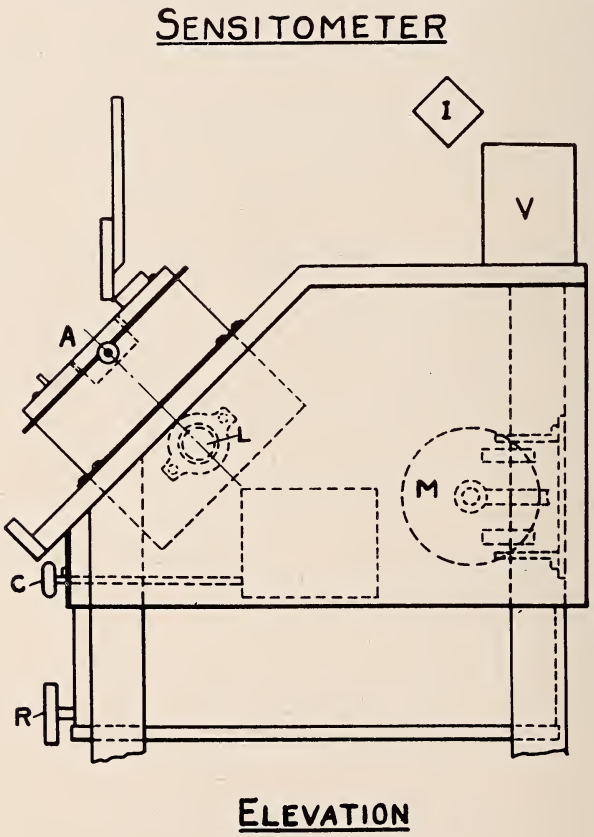


Fig. 10

or "Vitrolite" top, the reflected light from which is usually sufficient for inspecting film although extra illumination may be obtained by means of an inclined mirror (M) (Fig. 14) which reflects either daylight or light from the vapor proof enclosed lamp suspended above the table.

Waste scraps of film are swept into the film container attached to the right hand edge of the table. The container is fitted with a door

hinged at the upper edge so that it remains closed if the contents take fire, (vent holes are fitted at the side) but opens inwardly on pressure with the hand. The contents are removed by opening a sliding door fitted in the bottom.

Research Laboratory,
Rochester, N. Y.
May 8, 1924.

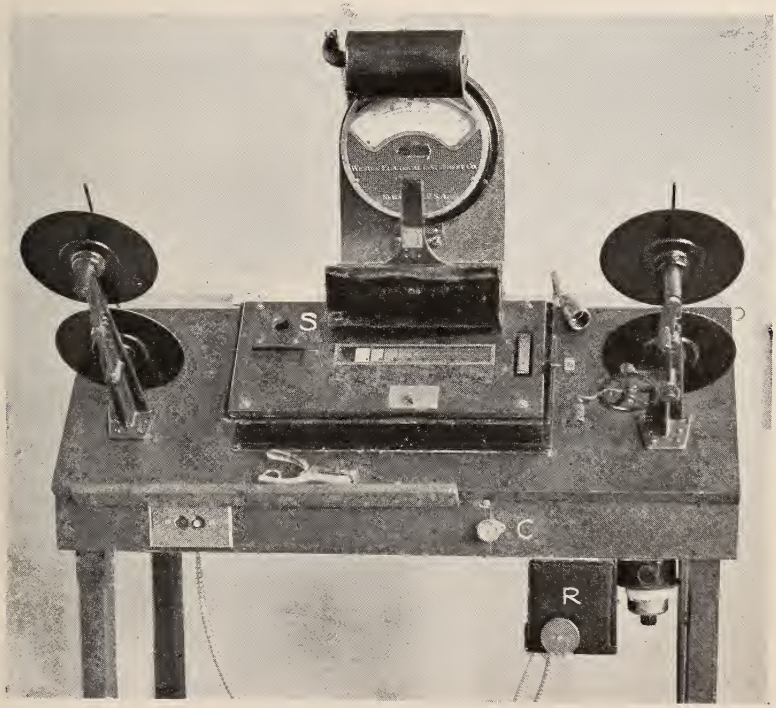


Fig. 11. Semi-Automatic Sensitometer.

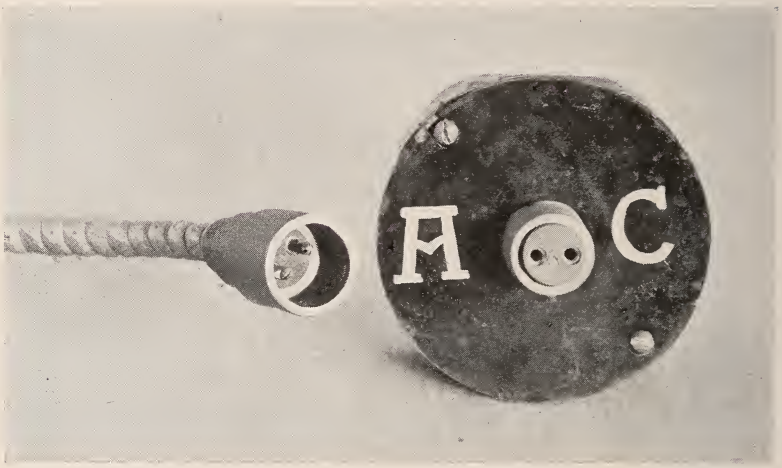


Fig. 12. Electric Plug and Socket.

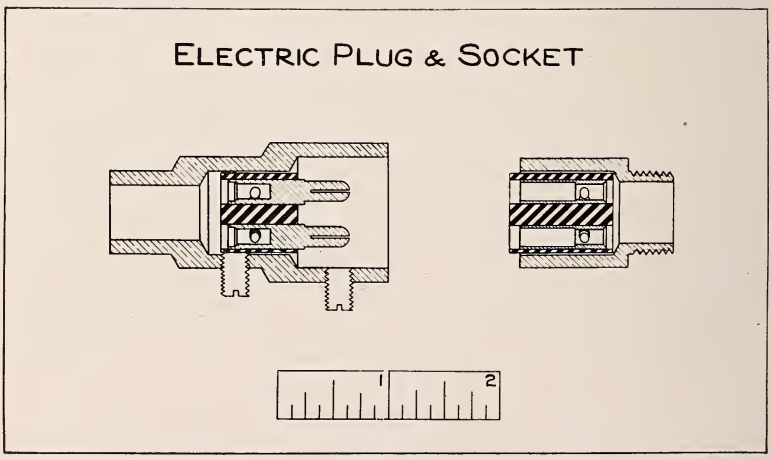


Fig. 13

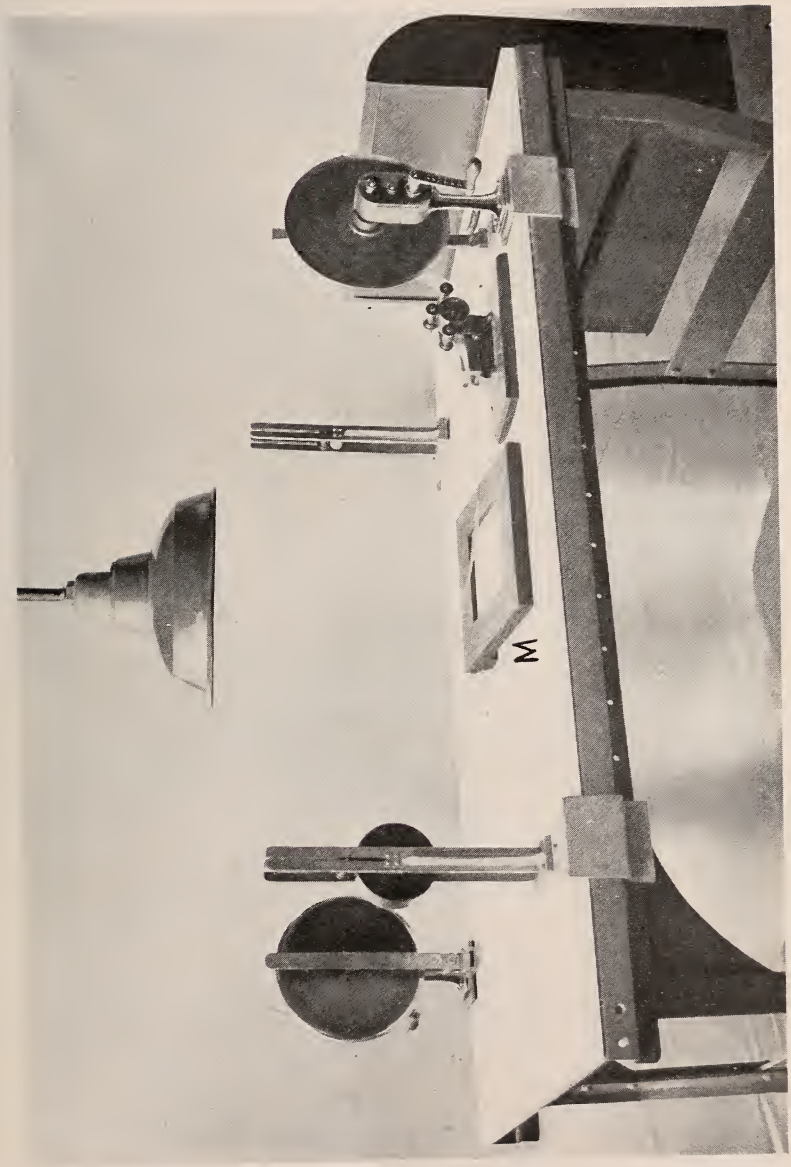


Fig. 14. Inspection and Assembling Table.

DISCUSSION

Mr. Mayer: Is the film in continuous motion while passing through the viewing machine?

Mr. Vinten: Is the machine fitted with a reverse so that it can be exposed again?

Mr. Crabtree: In answer to Mr. Mayer, the film is in continuous motion but the period of the flash is so short that you get an intermittent effect. There is some flicker, but the result is very satisfactory from the standpoint of inspection.

In reply to Mr. Vinten, did I understand you to ask if the camera takes care of double exposures? Yes, certainly. I will deal with that more fully in my paper to-morrow.

PHYSICAL PROPERTIES OF MOTION PICTURE FILM

By M. Briefer

Communication from the Research Laboratory of the Powers Film Products, Inc.

Synopsis

An analysis of the physical properties of motion picture film is attempted. The significance of the various factors involved in the tests and their relations, one to the other, are discussed. Some effort is made to relate the tensile strength of film base with its strength in motion picture film projection. Theoretical consideration is given to the relations existing between the plasticity of film base and the viscosity of its solutions. The effect of different conditions upon projection strength forms an important part of the work. Practical interpretation and application of the principles involved, are included in the study.

Introduction

IT IS a tribute to the ingenuity of man that he has been able to take a fibrous plant from the soil, a gelatinous material from the bones and skins of animals, the metals and salts of the earth and fashion these into endless ribbons of beautiful animated pictures to find their way into the life and culture and the educational advancement of the human race.

To a great extent, those interested in prolonging the life and usefulness of motion picture "prints" have the least control over the treatment they receive in commercial use.

The producer fashions his theme and makes his negative. Behind the magnificence of the portrayal, the laughter of comedy, the art, the science, the spectacular ensemble and hidden from the public are monumental difficulties, trials, tribulations and often a fortune involved.

The duration of useful life of prints rests largely with the exhibitor and, since the prints are only rented for short periods, the unfailing trait of human nature manifests itself in contempt for the value of that which belongs to another. But cost of production and cost of rentals inevitably seek a common level and so finally the exhibitor pays for the abuse which shortens the useful life of motion picture prints. A cooperative campaign of education and a systematic checking up of exhibitors who recklessly abuse or permit abuse of valuable prints may develop means for cutting down this annual waste. At the same time, raw film manufacturers should keep always before them the problem of improving their product to the end that such abuse as prints may receive will have less and less harmful effect. It is with this last thought in mind that the present study has been undertaken.

The work which follows is, for the most part, necessarily tabular and graphic, an attempt, however, has been made to offer as simple an interpretation as possible in discussing those problems which may be of direct and practical interest.

A strip of motion picture film is composed of a thin cellulose support about .005 of an inch thick coated on one side with a layer of gelatin less than .001 thick, the latter serving the purpose of holding the crystals of sensitive silver salts in position.

While the coating of gelatin reduces the flexibility of the cellulose support, it fortunately adds the necessary "body" to the film, for it will be shown that for equal thicknesses the coated film has far greater projection strength than the uncoated but more flexible base. This observation leads us at once to the conclusion that the edges of film should be carefully guarded against any practice which will injure or remove the gelatin coating even though such injury may not reach beyond the perforations. This condition is strikingly shown in an experiment to be described and illustrated later.

The first part of this paper will deal with the tensile strength and plasticity of nitrocellulose film base, both uncoated and coated; the second part with conditions affecting the projection strength of motion picture film.

Nitrocellulose film base is a flexible, plastic material which, however, undergoes gradual decomposition. Its plasticity is promoted by the presence of residual high boiling solvents or mincible non-volatile bodies. When warmed, the plasticity of the material is greatly increased. It has already been mentioned that gelatin coated film base has greater projection strength than uncoated film base of equal thickness and, since both plasticity and flexibility are reduced by the gelatin coating, it follows that beyond a certain limit, plasticity and flexibility decreases rather than increases the projection life of motion picture film. This is not difficult to understand when it is remembered that the cross section presented to the sprocket tooth must take the blow without appreciable yield. It is the constant excessive yield of the plain film base in projection which eventually tears the corners of the sprocket holes. The support or body which the less plastic gelatin coating gives to the film base, accounts for the enormous increase of the projection life of coated film.

We may anticipate a later treatment of the factor, that the condition of the physical contact of film base and gelatin determines the value of the combination with respect to its projection life. The degree of adhesion of gelatin to film base will be shown to have a marked influence on the useful life of the finished product.

The Physical Tests

The machine used in making the tensile strength and plasticity tests shown on the charts, is a Scott Serigraph. Any other standard tensile strength tester is, of course, equally adapted to such work; as for example, the Schopper machine.

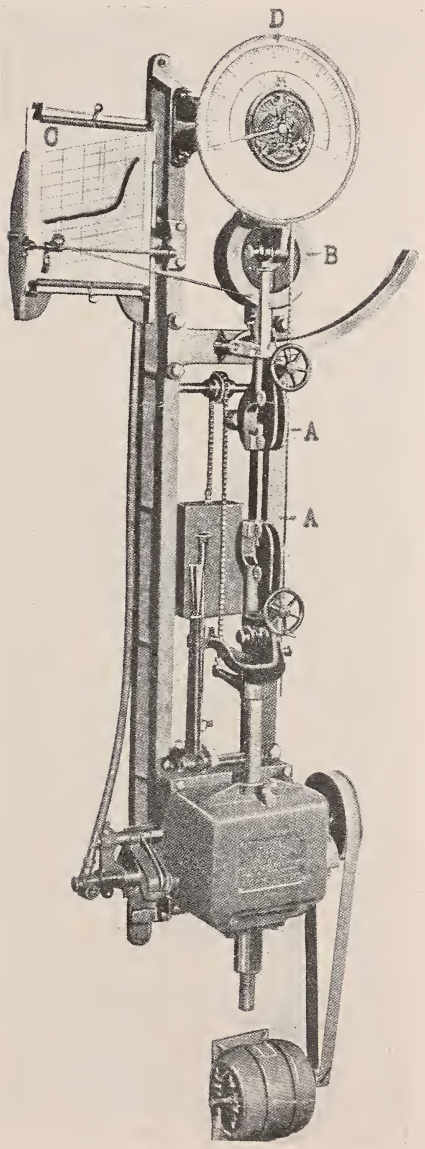


PLATE 1. Serigraph.

The sample to be tested is clamped squarely and firmly between the jaws AA (Plate 1). These jaws are caused to separate at a uniform rate. The upper jaw is linked with a pendulum weight (B). The swing of the pendulum, lift weight, etc., is indicated on a dial (D) and at the same time the performance of the test piece is automatically recorded on a chart (C). The physical characteristics mentioned are traced in a continuous curve during a single test. Chart (C) shows the characteristic curve of a strip of motion picture film base without gelatin coating.

All tests, except where otherwise noted, were made with jaws spaced 140 mm. apart, the rate of jaw separation 125 mm. per minute, width of the test strip 35 mm., which is also the standard width of motion picture film. The prevailing temperature and relative humidity are given with the other data where required.

In the tabulations, the values taken are the mean of at least six reliable readings. Such tests as were obviously in error due to some inherent fault of the strip have been rejected. The values tabulated have been further checked by a number of additional tests not here recorded. The material in each case was carefully prepared and minutely examined, the microscope being freely used especially in examining the condition of slit edges and perforations.

The physical properties of film base may be measured in terms of tensile strength, yield and elongation or plasticity. Tensile strength is the measure of the direct weight necessary to break a strip of film under load, while the yield is marked by a sharp rise in the curve at a point where the structure of the material begins to yield to the load applied. This is the starting point of the major elongation period, the latter also being a measure of plasticity. There is no sharp dividing line between plasticity and viscosity. We are accustomed to regard a viscous body as in a fluid state but we may imagine viscosity to increase until the body will no longer flow of its own weight. If however we apply force to such a body it will flow in some relation to the applied force, deforming the material until the structure is ruptured.[1]

In considering deformation as a consequence of the applied force, we have in mind a ribbon-like material such as cellulose film. Plasticity of other bodies or different forms of cellulose products are measured by other suitable means. It is sufficient for the present purpose to consider only the resistance to deformation and the percent elongation as relative measures of the plasticity of motion picture film base.

[1] Bingham and Green differentiate between Viscosity and Plasticity. American Society for Testing Materials, Vol. XIX–1919.

For a study of viscous and plastic flow see also Booge, Bingham, Bruce—Relation of Yield Value and Mobility. A.S.T.M., Vol. 22—1922.

Journal Industrial Engineering Chemistry, Vol. 14—Nov. 1922.

A study of Nitrocellulose—Bingham and Hyden. Journal Franklin Institute —December, 1922.

A number of interesting effects are noted in performing the physical tests and if not taken into account will give very misleading values. For one thing, the condition of the edges play an important part. A clean cut edge is absolutely necessary in order to arrive at comparable results. Mr. F. W. Crawford in the course of a joint investigation first called my attention to the fact that even a slight nick, so slight as to be imperceptible to the naked eye, will shorten the elongation curve fifty per cent and more. A very light scratch on the celluloid side, if it reaches the edges of the film, will have the same effect. This is what one might expect, but it is surprising to note that a similar scratch on the gelatin side of coated stock will give a premature break though only the gelatin appears to have been penetrated.

Since temperature greatly affects plasticity, this factor must be kept constant if reliable readings are to be had.

Fortunately, the yield point is least affected by changes in conditions other than temperature. This factor is, in our opinion, the most reliable index of the quality of film base. For base of the same composition, the yield point is directly proportional to the cross section area. Tensile strength and elongation are variable factors requiring, as already stated, precise conditions for even approximate values; but it will be shown that for stock of the same composition, the yield point is the basis for a simple calculation, or at least for a very close estimation of the values of other physical factors.

The Yield Point

The yield point is defined as the elastic limit to a shearing stress, and is equal to the friction constant, at which stress the body begins to yield or deform. The deformation which we are considering as taking place, is irreversible—remaining permanent after the stress has been removed, and is distinguished from reversible deformation in the case of which the body recovers its original form. If a length of cine' film is fashioned into a continuous ring or loop, the ring may be altered or deformed by pressure and within the elastic limit of the material, will resume its original shape when the pressure is removed. If, now, the loop is depressed or flattened out over its full diameter, the ends will be folded or creased and if the pressure is sufficient, the loop will not again resume its original shape. At two points where the depressed loop is folded, the elastic limit has been exceeded and the deformation is permanent. On removing the pressure, the loop may take some elliptic form, but if the stock is brittle, it may crack at the folds and we will have two strips of about equal length lying flat, one upon the other.

This simple experiment serves the purpose of one test for determining the relative flexibility of cine' film while an extension of the experiment is used for an approximate determination of brittleness.

The yield point, or elastic limit, is usually found from the chart at a point in the curve where the material just begins to deform

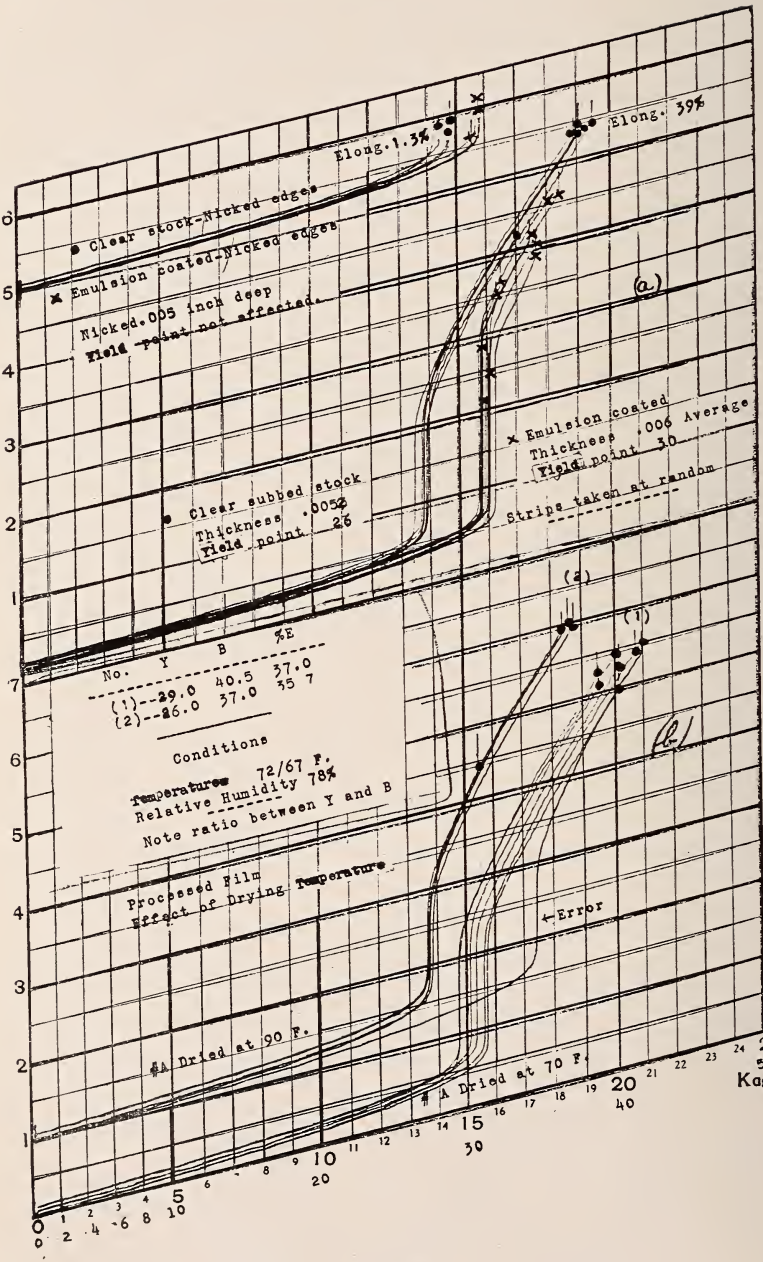

Elong. 1.3%
Elong. 39%
● Clear stock-Nicked edges
× Emulsion coated-Nicked edges
Nicked .005 inch deep
Yield point not affected.
(a)
× Emulsion coated
Thickness .006 Average
Yield point 30
● Clear subbed stock
Thickness .005
Yield point 26
Stripe taken at random
(a)
(1)
No. Y B %E
(1)--29.0 40.5 37.0
(2)--26.0 37.0 35 7
Conditions
Temperature 72/67 F.
Relative Humidity 78%
Note ratio between Y and B
Processed Film
Effect of Drying Temperature
←Error
#A Dried at 90 F.
A Dried at 70 F.
Kas.

PLATE 2

sharply. There are instances when it is difficult to decide upon the precise position of the yield point but as a rule, the shape of the curve permits of little doubt. W. F. Edwards, in the November 1922 issue of "Silk," suggests that the elastic limit point be found by making a tangent to the curve from the starting point.

There is objection to this method in cases of very rapid deformation, tracing a curve "X" as shown in Fig. 3. Compared with curve "Y," it is easy to see that the resistance to deformation is greater in Y than in X and that therefore the elastic limit point of the two curves cannot be coincident, as they are shown to be, by making a tangent to the curve from the starting point.

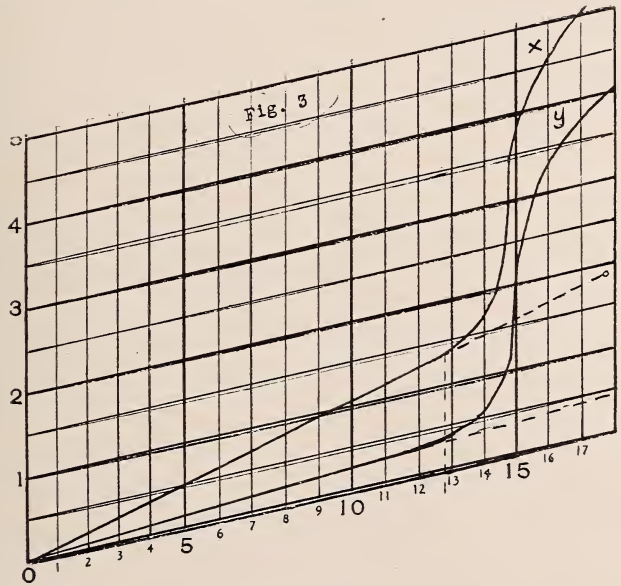


Fig 3

Moreover, in dealing with such plastic bodies as nitrocellulose film, deformation begins almost as soon as the stress is applied and some account must be taken of the rate at which this deformation accelerates with increasing load. Until something better can be worked out, the position of the yield point must remain an arbitrary choice and suited to the particular material under test.

For our present purpose, the most reliable method of finding the yield point, is on an horizontal line intersecting the curve a vertical distance 0.5 cm. (0.475 actual—see plate 5) above the starting point. This is equal to an average of about 10% of the total elongation of a strip of motion picture film base, .005 inch. thick, 35 mm. wide, 140 mm. long; deformed at temperature 20° C. It must be admitted however that this choice is purely arbitrary and not indicated by

mathematical considerations other than that it is in agreement with the relative values found.

With elastic bodies, deformation is not necessarily coincident with rupture. The deformation may consist merely of an alteration in the shape of the individual particles composing the body, in which case, though the form be altered, the total cubic area would remain unchanged.

Careful measurement of a given section of material at points below, at and above the curve of greatest deformation, may develop interesting and valuable information.

The importance of the yield point as a physical property of nitrocellulose film will be seen from a study of the graphic charts included in this work. In all probabilities, the yield point is related in some manner to the viscosity or composition of the cotton solution from which the skin is cast.

J. O. Small and C. A. Higgins, in the "Chemical Age" June 1920, suggest that,

> "The strength of film which may be deposited from a solution of nitrocellulose is dependent probably more upon the viscosity of the nitrocellulose than upon any other factor.—The length of the fibre of the nitrocellulose is another property affecting the strength of the film and is dependent upon the length of the fibre of the cellulose and upon the severity of the purification treatment given the nitrocellulose."

It is doubtful if the length of the fibre has a direct influence upon the strength of the film; but the difference in fibre lengths may be expected to affect the viscosity of the nitrocellulose or the control of viscosity in nitration and subsequent operations, for much depends upon the packing of the fibres and their biological history.

There appears to be very little work published in connection with nitrocellulose film but according to Bingham (Fluidity and Plasticity 1922), W. L. Hyden has made a study of the property of solutions of nitrocellulose in acetone (Thesis Lafayette College 1921). Hyden finds the mobility of nitrocellulose solutions to increase with the temperature in a nearly linear manner and that the mobility falls off very rapidly with increasing concentrations of colloid. A more intensive study of the relation between the physical properties of nitrocellulose solutions and the skin deposited from it, may help in the development of motion picture film base of greater strength and utility.

Elongation

Elongation is calculated as per cent stretch of the original length of the test piece subjected to the pull, and is read from the chart as the vertical distance from the starting point. The breaking load value which is the measure of tensile strength, is entirely dependent upon the true record of elongation and much confusion has resulted from a misunderstanding of these relations. This dependence of the break value upon the true value of elongation is easily seen

in the proof that an imperfectly cut edge shortens the elongation period enormously. This condition is strikingly shown in the reproduction of the original chart (a), plate 2. The true elongation of a sample of subbed stock, uncoated, proved to be 39%. The elongation of strips cut from the same sample, nicked at the edges to a depth of about .002 inch, is reduced in value to little over 1.3%. To a somewhat less degree, the same holds true of the sample after coating with emulsion.

If, then, the elongation is so affected, the tensile strength value cannot be determined.

By referring to plate 3, it will be seen that the elongation is affected but little by differences in temperature but that the yield and break values are affected in linear ratio. If this is true, then the values for yield, elongation and break may be correctly determined for any given sample by testing at a number of different temperatures. The interfering defects of the test pieces will be corrected by the effect of temperature and the ratios indicated. A more detailed treatment of these points will be given presently.

The ratio between yield and break points for any given sample is again shown on chart (b), plate 2 (processed film dried at 70° and 90° F.). As before, the higher temperature has shifted the yield point but had practically no effect upon the elongation curve.

Break or Tensile Strength

This is regarded, and rightly so, as the most important single factor in the estimation of the value of nitrocellulose film, fabrics and textiles generally. The misbehavior of this test has occasioned many difficulties. We have already noted its absolute dependence upon elongation. The value of the test is so entwined with the other physical properties that little can be added here which is not already included elsewhere in this study.

Effect of Temperature

In doing this work, care was necessary to subject each test strip to a uniform quantity of heat both as to intensity and time. The apparatus finally determined upon was an electric reflecting heater of sufficient size to focus a uniform intensity of heat over the full area of the strip under examination. The temperature at the position of the test strip was controlled by varying the distance of the heater. When the adjustment of the reflecting heater was such that the temperature remained constant for five minutes, the test strip was clamped in position.

Within reasonable limits, the time of exposure to heat at temperatures not exceeding 30° C. appeared to have little effect. At the higher temperatures, appreciable softening takes place which naturally influences the results. For this reason, a safe period of time was first determined experimentally and then applied to all tests alike.

Two minutes was found sufficient for the test pieces to acquire the desired thermal condition at all temperatures used.

The effect of temperature on cinematograph film base, uncoated and unsubbed, is shown graphically on two charts (a and b), plate 3.

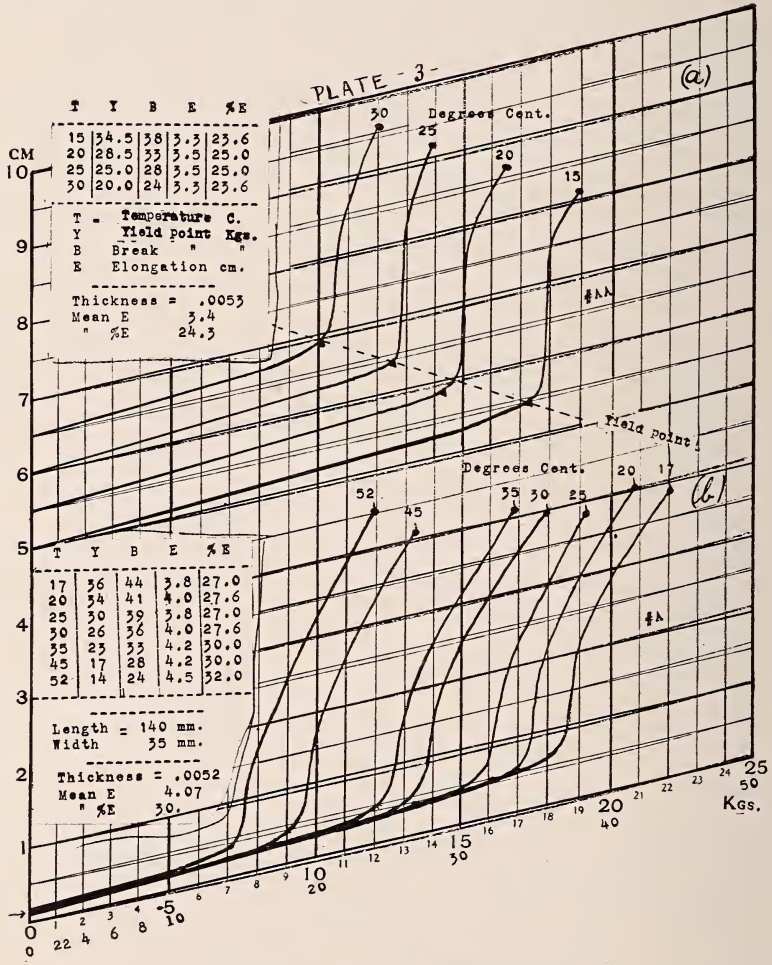


Plate 3. Effect of Temperature.

The mean of nine readings for each test is tabulated at the head of each chart. The values found represent stock of two different American manufacturers. The physical characteristics suggests considerable difference in the chemical composition of the two specimens and an analysis indicates a difference in the percentages of high boilers and residual solvents. As suggested elsewhere, the

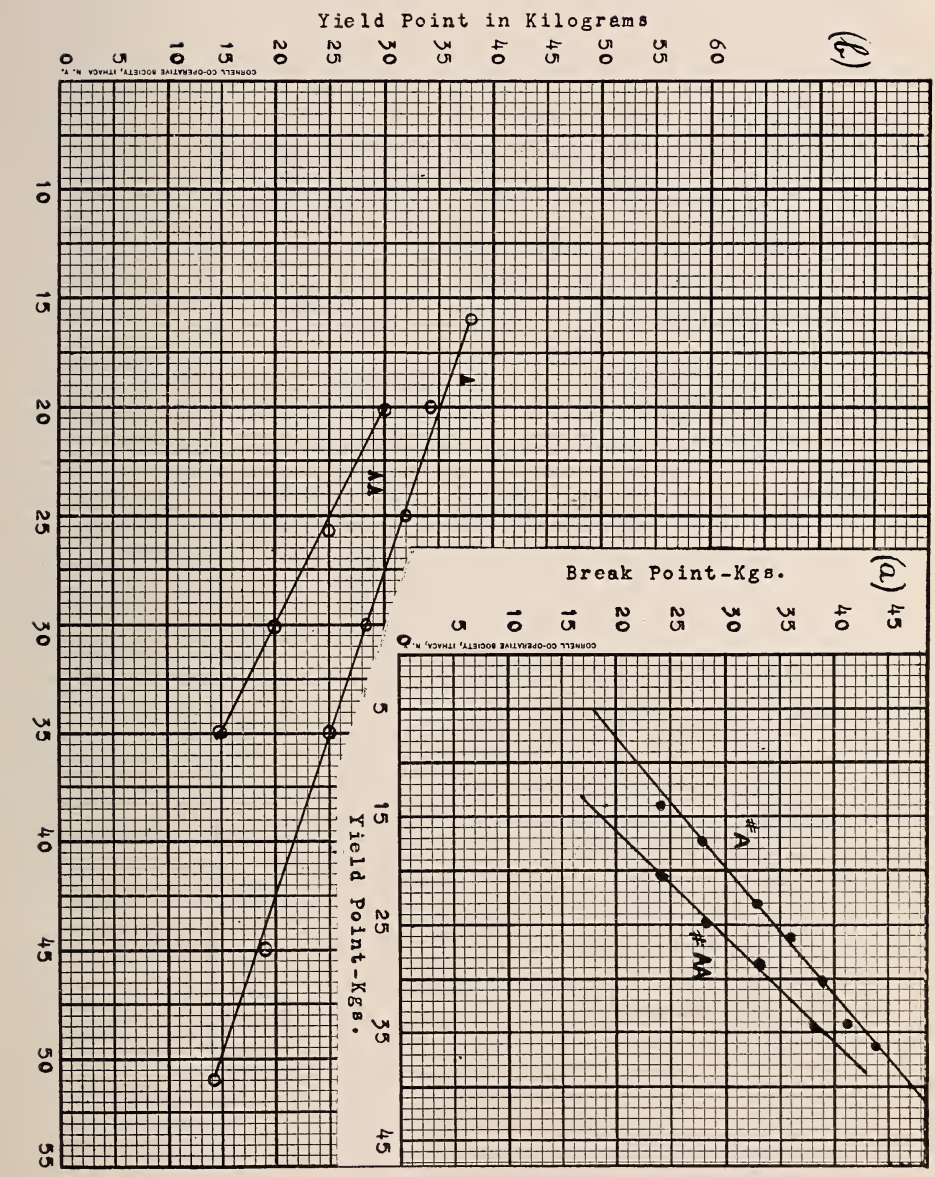


PLATE 4. Nitro-Cellulose Film Base — Temperature Centigrade

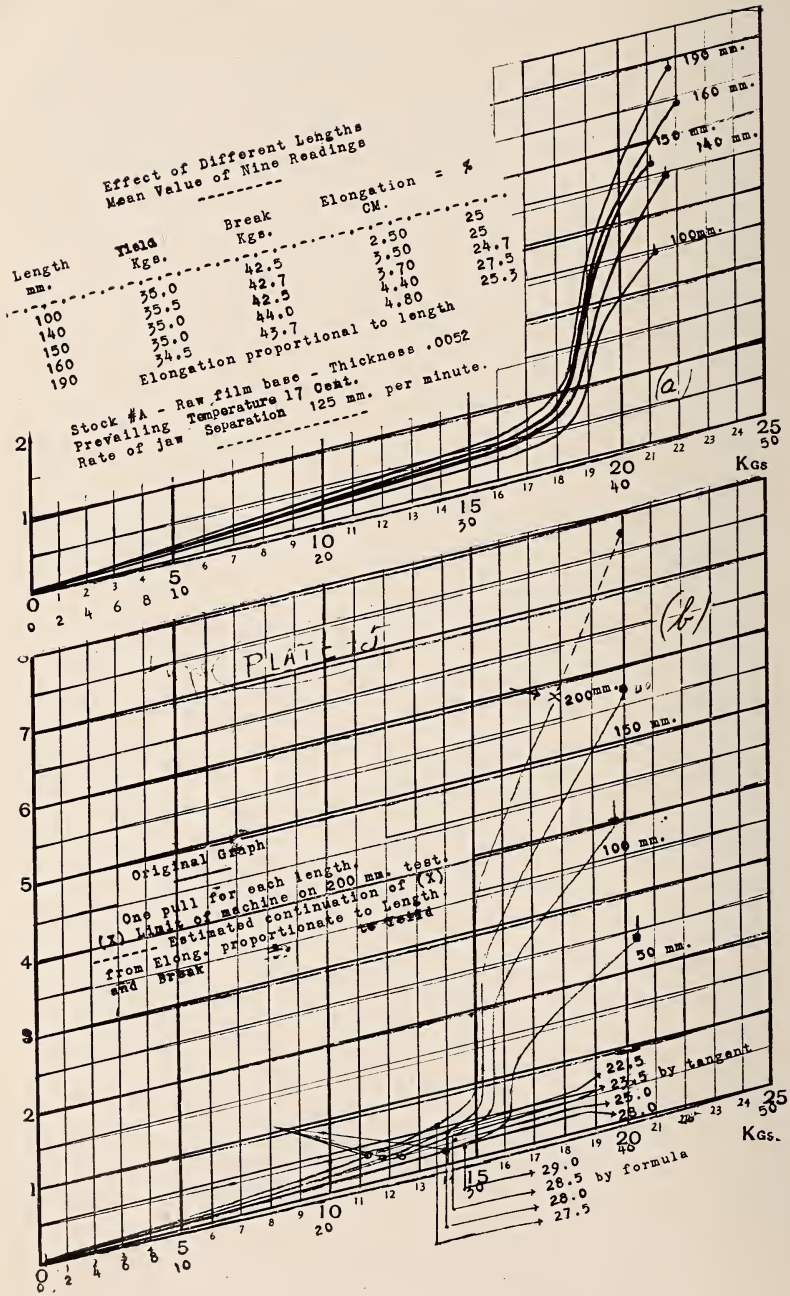

Effect of Different Lengths
Mean Value of Nine Readings
Length mm. | Yield Kgs. | Break Kgs. | Elongation = % CM.
100 | 35.0 | 42.5 | 2.50 | 25
140 | 35.5 | 42.7 | 3.50 | 25
150 | 35.0 | 42.5 | 3.70 | 24.7
160 | 35.0 | 44.0 | 4.40 | 27.5
190 | 34.5 | 43.7 | 4.80 | 25.3
Elongation proportional to length
Stock #A - Raw film base - Thickness .0052
Prevailing Temperature 17 Cent.
Rate of jaw Separation 125 mm. per minute.
190 mm.
160 mm.
150 mm.
140 mm.
100mm.
(a)
Kgs
PLATE 15
(b)
200mm.
150 mm.
100 mm.
50 mm.
Original Graph
One pull for each length.
(X) Limit of machine on 200 mm. test.
Estimated continuation of (X) from Elong. proportionate to Length and Break
22.5
25.5 by tangent
25.0
26.0
29.0
28.5 by formula
28.0
27.5
Kgs.

PLATE 5

viscosity of the nitrocellulose, the bicological history of the cellulose and probably the kind of solvents as well as the conditions of casting the skin, have much to do with differences in the physical performance of film base.

The important effect of temperature, as may be expected, lies in the shifting of the yield point, since, with the application of heat, the plasticity of the body is increased in much the same way as the viscosity of a solution is altered under like conditions.

Two interesting features are developed in these experiments; first, that the elongation or, per cent stretch is practically unaffected between 15° and 30° C. and is increased but little at the higher temperatures, and second, that the yield point is a linear function of the temperature, so that if two or three points reasonably separated are determined and plotted on a chart, a line drawn through them will cut the yield point for any temperature within practical limits. Chart (b), plate 4, shows temperatures plotted against yield points for both specimen A and AA film. It is also interesting to note the difference in the slope of the two lines representing the yield points of the two specimens. If these lines are prolonged so as to cut the yield point axis at zero, specimen A will cut at temperature 72.5° C. while specimen AA will cut at temperature 50° C. This would indicate the respective softening points of the two specimens in question.

Effect of Different Lengths

Chart (a), plate 5, shows the effect of different lengths of test strips over a range of from 100 mm. to 190 mm. between the clamps of the Serigraph.

Of special significance is the fact that the yield and break values are only slightly affected by differences in length. The per cent elongation is, of course, proportional to the length of the test strip.

Reference to the special chart (b), plate 5, will show that as the length of the test piece is increased, the rate of deformation rises somewhat and if we locate the yield value for a 100 mm. length at a point where the curve intersects an horizontal line, a vertical distance of 0.25 cm. above the starting point, then the location for the other lengths corresponds to the formula,

$$v+\left(\frac{dv}{100}\right)=v^1$$

where (d) is the difference in length, (v) the vertical distance given and (v^1) the vertical distance sought. From this, if the yield point for 100 mm. length be located at $v=0.25$ cm., then at length 200 mm., $v^1=.625$ cm. which is substantially correct. Similarly, for 140 mm. length (the length here used in general testing) the yield point will be located at $v^1=0.475$. This also agrees very well with the value found on the original graph.

How well this relation agrees with film base of widely different physical properties has not been definitely determined. It is, however, obvious that the base value ($v=0.25$ cm.) for the dimensions

of the test strip given in this experiment, cannot apply generally. But it appears, from work already done, that the ratio for varying lengths will be proportional if the base value for 100 cm. length is first found, taking the mean of a number of readings for any particular class of film base under investigation.

Apart from any speculation or study these factors invite, they may serve as a means for developing more accurate methods of determining the physical values of motion picture film.

Effect of Different Thicknesses

Work on this phase of the subject is still in process but enough has been done to show what may be expected. The investigation is hampered by the difficulty of obtaining reliable specimens properly related as to thickness and composition. Merely selecting specimens of different thicknesses at random would avail little. The film should be cast from the same lot of cotton solution and as nearly under the same conditions as possible.

The portions of the samples used in this investigation were selected with considerable care and are five in number, of thicknesses .0042, .0044, .005, .0052 and .006. They represent, however, specimens of two different manufacturers and are therefore not likely to be similar in composition.

Between .0048 and .0052, other things being equal, the projection strength of nitrocellulose film is nearly linear. Above .0052 the projection strength rises sharply and below .0048, falls off rapidly; in both cases, out of all proportion to the difference in thickness, suggesting the curve shown on plate 6. The projection strength for different thicknesses is tabulated below, the figures under "projection strength" representing the number of complete trips through the wear and tear machine. (Fig. A.) The values give the average of a number of readings and may be regarded as reasonably reliable.

Specimen		*Pro. Str.*	% $A = 100$
A	.006	1124	100.0
B	.0052	343	30.5
C	.005	304	27.5
D	.0044	183	16.3
E	.0042	102	9.0

In examining different samples of film base it was found that mere thickness does not necessarily imply proportional tensile strength or projection strength. This is what we should expect unless the samples were known to be composed alike in every particular. For example, one specimen of American raw stock, thickness .005, gave a projection strength of 334 and has a value of 30 in the above percentage column, while a specimen of foreign

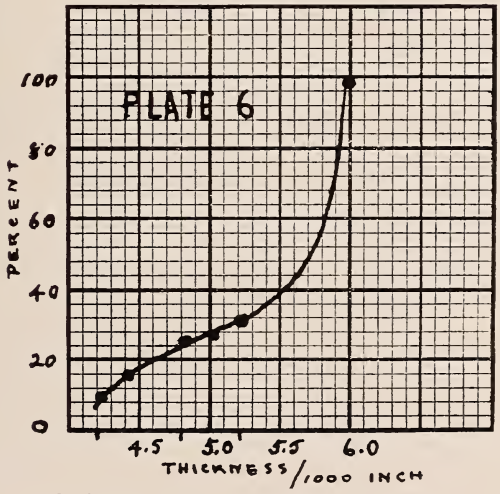
manufacture, thickness .00525, had a projection strength of 91 and a percentage in the above column of 8. It will be seen from the projection strength experiments to be described that many variables are met with and unless their influence is recognized and accounted for, much confusion will develop with little hope of comparable results.

*Plate 3 shows two specimens of film of nearly equal thickness, differing widely with respect to yield point and proportionately as to the effect of temperature. They behave toward each other as if we were dealing with two colloid solutions of different concentrations.

Effect of Thickness

Thickness Inch.	Yield Kgs.	Break
.0042	29	33
.0044	32	38
.005	34	42
.006	44	— *over 50

* Beyond limit of machine.



Relative Projection Strength (see page 190)

If we recognize that the plasticity of nitrocellulose film is analogous to the viscosity of its solutions, then we have the answer to the difference in yield point value of the two specimens of equal cross section area and also the whole system of the physical tests described becomes intelligible and applicable in principle, to projection strength.

It is tempting to invite the imagination to dwell upon the probable, ultimate structure of nitrocellulose film which these different

*Note: Unfortunately there was not enough of specimen AA to determine its relative projection strength.

phases suggest and we would linger for a space among these submicroscopic things, if only in imagination, were it our plan to do so at this time.

Projection Strength

When we inquire how the properties of nitrocellulose, so far developed in our study, may be directly applied to the strength of the finished print in projection, we are confronted with some difficulties. Certainly scratches either front or back can be regarded as no more than blemishes since the load required to break the film is always beyond the yield point and this, even in perforated stock, is well above any longitudinal stress to which it may be subjected in practice. Nicks and rough edges are entitled to the same immunity. From the same reasoning, the break point should be regarded as of secondary importance though tensile strength should normally constitute a prime factor. It is so considered in textiles and other fabrics for the obvious reason that these materials are subject to stresses corresponding to the load applied in tensile strength testing.

With motion picture film we face an altogether different condition. We have friction in the gate of projection machines and short, sharp blows from the intermittent sprocket mechanism directly against the cross section of the film. This last is the outstanding feature which makes for long or short projection strength.

If the cross section, that is, the edge of the sprocket hole, receives the blow squarely, practically in a vertical plane to the bearing face of the sprocket tooth, then the full value of cross section strength is obtained. If, however, the edge of the sprocket hole is curled either toward the emulsion or the film base, then the print is indeed very short lived, for it is easy to see that any yield of the edge to the blow of the sprocket tooth will soon develop cracks in the corners of the perforations. If the film is too flexible—too soft—the same thing will happen. In this connection it seems to make little difference whether the new round corner or the Bell & Howell standard perforation is used. This point will be clearly understood from an examination of plate 7 and 8, slides of which you will see on the screen presently.

The most severe single damage any motion picture film can receive is quick drying at high temperature and low humidity. This procedure gives the film a definite curl which cannot again be removed sufficiently to offset the total damage done. And, it should be remembered always that not only does the film curl lengthwise but every edge of every perforation curls in proportion.

Raw Stock

So far we have dealt mainly with film base or uncoated stock. The greatest interest, however, attaches to coated film or "raw stock" as it is termed in the trade.

Before coating with emulsion, one side of the film base is treated so that the gelatin will adhere. At this point in the manufacture of

raw stock a very delicate balance is required. Few, outside the laboratories of motion picture film manufacturers, realize the delicacy of this operation nor the vigilance required to avoid heavy losses should this balance be upset. The condition of adhesion must be such that

PLATE 7

the gelatin is free to "creep" along the surface of the film base and yet not leave that surface. The swelling of gelatin and the unequal expansion of gelatin and film base makes this problem one of considerable difficulty.

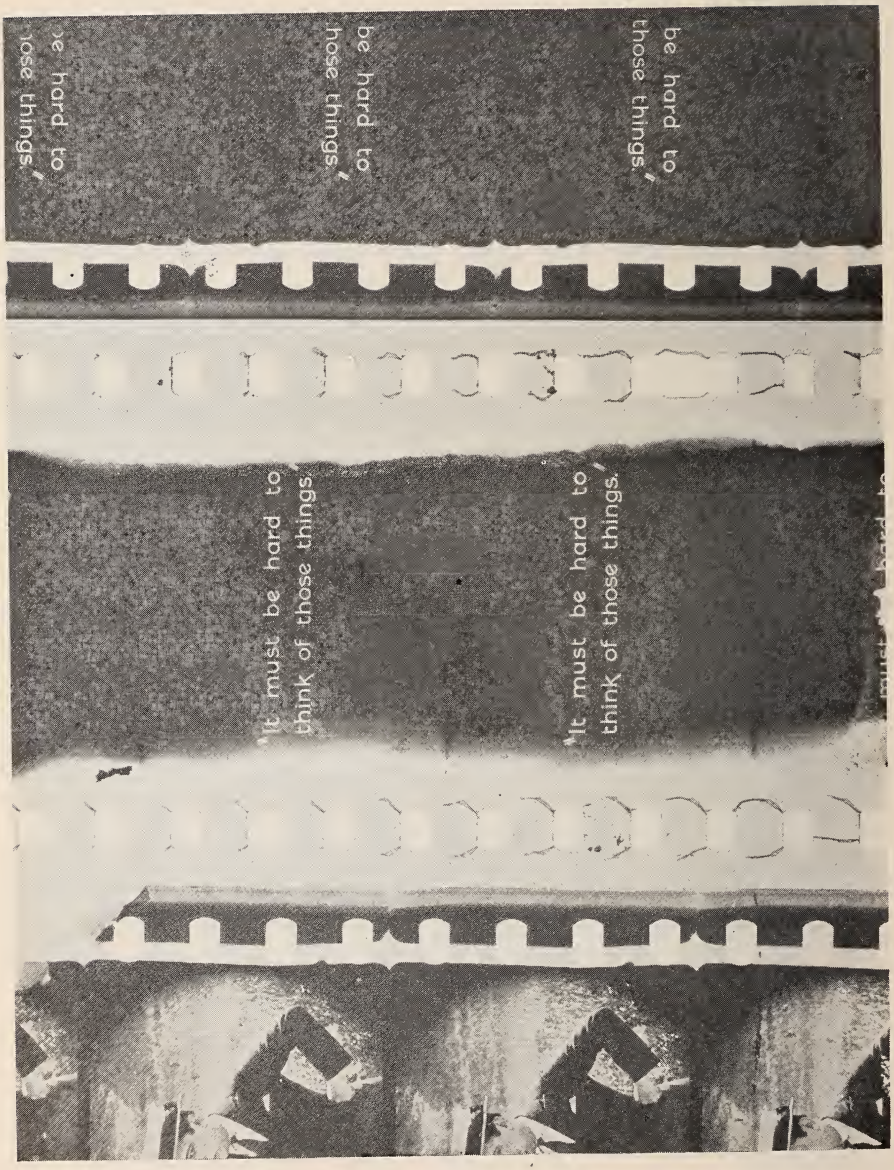

be hard to
those things."
be hard to
those things"
be hard to
those things."
"It must be hard to
think of those things
"It must be hard to
think of those things."

PLATE 8

Briefly stated, the treatment mentioned consists of applying to one side of the cellulose skin an alcoholic solution of gelatin, called substratum or simply "sub" to which the subsequent emulsion coating will adhere. A number of other "subbing" methods not involving the use of gelatin have been tried among which is the practice of etching with ether and other solvents.

Whatever the practice may be, it is simple to err on the safe side and create a condition when the gelatin adheres too firmly to the film, in which case, felting between the base and gelatin occurs. It will be shown that this condition favors so called brittle film.

Photomicrograph A.
(coated film)

Effect of Adhesion
Edge (a) premature fracture from too much adhesion
Edge (b) Correct adhesion; shows full resistance to breaking load. Film base break independent of gelatin.
Black spaces are emulsion coating.

Gelatin, when dry, is quite brittle as compared with the film support. If the gelatin coating and film base are felted by reason of too great adhesion, then any fracture of the gelatin carries also through the base. Both gelatin and base crack and the raw stock or finished print breaks in two. On the other hand, when the correct condition of adhesion is obtained, the gelatin, because of its ability to creep along the surface of the film support cracks first, the film base holding its original flexibility. Photomicrograph (A) shows the effect of the break in the tensile strength tester on brittle and non-brittle film. Edge (b) shows where the gelatin has broken away from the film base. Edge (a) shows the strong adhesion of the gelatin. In other words, the gelatin and base are firmly cemented. This is practically the whole story of brittle and non-brittle film, except that

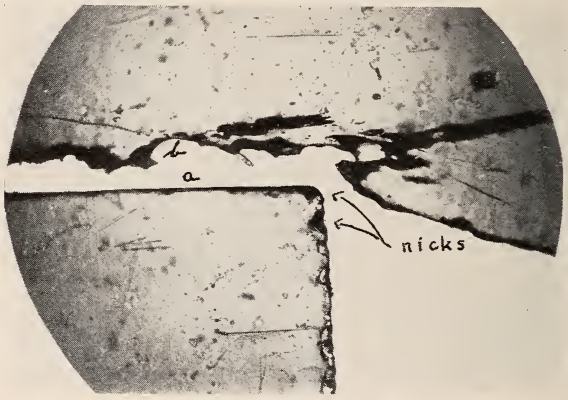
any product may be rendered brittle by abuses in processing and thermal conditions of shipping and storage.

In performing the following experiments, untreated film base was used and so coated that in one case we have correct adhesion while in the other, too much adhesion. The difference between the two specimens will be more clearly understood from the projection tests described at the conclusion of this study.

Fig. B shows a diagram of the apparatus used to determine brittleness. It is extremely simple but effective. As a matter of fact, no apparatus is needed. The edge of the hand may replace the rubber faced drop.

A strip of film, six inches in length, is folded in a loop, gelatin side out. The ends are slipped under the metal band so that the

Photomicrograph B.
(uncoated film)



Effect of Nicked Edges
Edge (a) clean fracture and premature break from nicked edge.
Edge (b) showing full resistance to breaking load. Edges clean cut.

loop will be directly under the rubber faced drop. The drop is released and falls by gravity squarely upon the loop. If the film is brittle, it will break in two at the impact; if not brittle, it will merely be sharply folded and the gelatin may have cracked at the fold or not, depending upon the dryness of the test piece. Louis Schopper manufactures a fold tester intended to measure the fold strength of sheet celluloid and other products. It is intended to indicate the flexibility or brittleness of such bodies. For testing cine film, it appears of doubtful value for the heavier stock survives the least number of folds. The machine probably gives comparative values for stocks of equal thickness. The difficulty, perhaps, lies in the fact that the outside of the fold moves over a longer arc with the thicker material and also the pressure is greater. A shearing stress is set up and the move-

ment of the particles is further accelerated by the kinetic energy developed. Film .003 inch thick will actually survive four times the number of folds of .005 and about ten times that of .0075 in thickness.

The conditions developed in making the loop test described are shown in the two slides (B) and (C). (Plate 9.) The first shows how the gelatin has broken, leaving the base whole, and the second, the sharp, clean break of the entire structure. The gelatin and base have broken simuleaniously. The fracture is that of a brittle body.

There remains but one experiment before examining the conditions affecting the projection life of finished motion picture prints. Chart (b), plate 2, shows two curves of processed film. For

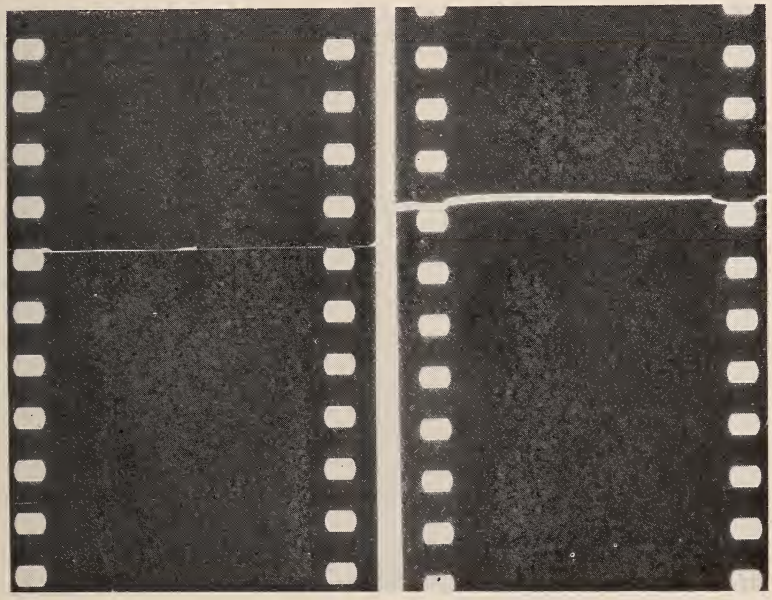


Plate 9

this experiment unperforated stock was simply flashed, developed, fixed and washed. The test piece was then divided into two equal parts and one dried at 70° F., relative humidity 68%; the other dried at 90° F., relative humidity 29%. The drying was done on small rotating drying drums and the time allowed for drying, as experimentally determined beforehand, was twenty minutes.

The portions selected for this test were exposed together in a chamber to a temperature of 70° F., relative humidity 68% (the drying conditions for specimen 1) and allowed to remain therein for one hour and 45 minutes before undertaking the test. The curves show that specimen 2 has not reabsorbed moisture equivalent to

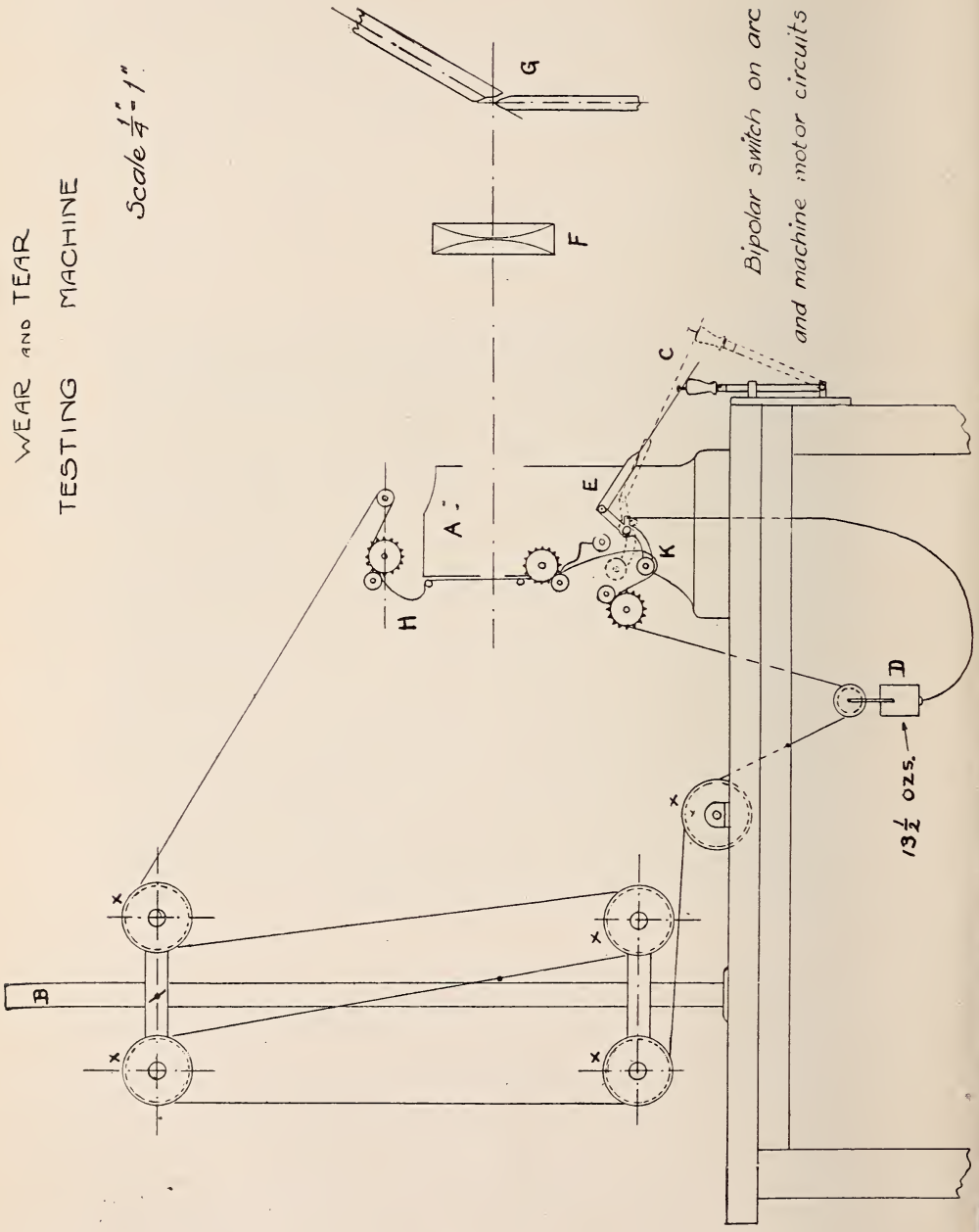

WEAR AND TEAR
TESTING MACHINE
Scale 1/4" = 1"
Bipolar switch on arc
and machine motor circuits
A
B
C
D
E
F
G
H
K
13 1/2 ozs.

Fig. A

specimen 1 and that the high drying temperature of specimen 2 has left its permanent effect upon the condition of the gelatin coating. Whether exposure to higher degrees of humidity, or for longer time, would change the relative values found, has not yet been determined.

Wear and Tear Tests

Processed Film

Apparatus used:

The machine used for this purpose is shown diagrammatically in Fig. A. The projection head *A* is mounted with aperture facing, film support *B*, to which is attached, on arms, loose rollers *X*, the

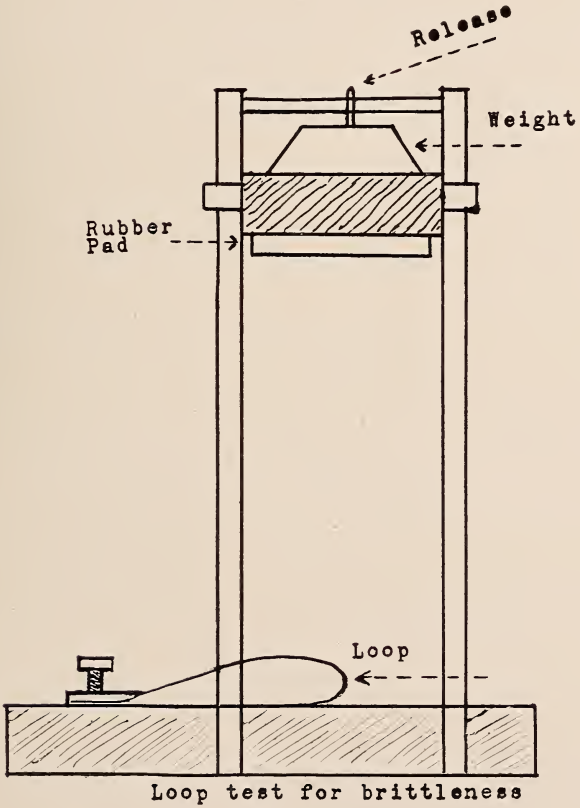


Fig. (B)

upper pair of rollers on support *B* being adjustable. A bipolar switch *C* is operated by lever *E*. The weight *D* takes up the slack of the film and furnishes the required tension for the sprocket mechanism. The arc is at *G*; the condensing lenses at *F*.

The mode of operation is as follows:

A ten foot strip (160 pictures) is selected and the perforations examined to see that all are in good condition. The strip is joined to form a continuous loop and threaded in the manner shown. It is important to have upper loop *H* exactly the same size for all tests, (namely, four pictures between engaging sprocket teeth) as otherwise, the tests will not be comparable. It is likewise important to have the gate tension uniformly set, since the duration of the test varies with the difference in tension applied at the gate.

The pressure plate is so adjusted as to give approximately three hundred and fifty complete revolutions of the ten foot loop for any selected standard. The idle rollers marked *X* must be well lubricated in order to avoid variable frictional resistance. The machine head and all its parts are to be periodically cleaned and ubricated.

After the machine is threaded in the manner described, the switch is closed and the arc adjusted in the usual manner. The machine is then started and the test is under way. The perforations gradually wear from the continuous passage of the film through the gate and when they break, loop *k* is shortened, throwing lever *E* which operates switch *C*, thus disconnecting the circuit for both machine head and arc. A revolution counter is so attached as to indicate the number of times the complete loop has passed through the gate. The mean value of a number of reliable tests is taken as the useful projection life of the film.

For comparative values, the conditions of the test must be uniform as to setting of machine, temperature, relative humidity and adjustment of arc. Comparable results may be obtained also without the use of the arc as will be shown later. The projection head used in these experiments was manufactured by Nicholas Powers.

Effect of Gelatin Coating

It would be very desirable from the standpoint of economy and cleanliness, economy in the saving of emulsion and cleanliness in perforating, if the perforated edges were left uncoated.

From time to time the advisability of such a procedure has been raised and considerable experimental work has been done to perfect machines for coating in this manner, but unless some means are devised to overcome the disadvantages of this procedure, the following experiment appears to dispose of the matter as highly undesirable.

The experiment in question was conducted as follows:

A ten foot strip of processed film was freshly prepared under conditions assuring minimum and uniform shrinkage. At intervals of 24 inches on both sides of the strip, the gelatin coating was carefully removed from the perforated edges, leaving only the film base to engage the sprockets. The strip was then spliced into a continuous loop in the manner described for wear and tear tests. The loop was then run through the wear and tear test machine,

in order to determine the relative strength of the coated and uncoated portions of the strip. The following mean values of four readings for both coated and uncoated sections were obtained.

Specimen	Number of Trips *Clear Base*	*Coated Base*
1	105	469
2	76	309

This considerable difference in the projection strength of the treated and untreated portions of the film cannot be accounted for by the difference in thickness alone. An examination of the character of the break would indicate that the low value for clear base is due to flexing or yield at the perforation edges to the blow of the intermittent sprocket. The condition is shown on the reproduction of several test sections which have also been mounted as slides to be shown on the screen. (Plates 7 and 8.) It is evident that where the gelatin on the perforated edges is worn thin from excessive friction in the grate of projection machines or, from failure to properly wax the film, the useful life of the "print" will be greatly reduced.

Wear and Tear Tests

Four rolls of cinematograph film of different physical characteristics were taken for the following series of experiments. The specimens are designated as follows:

(*m*) Non-brittle, curly. (*s*) Brittle, non-curl.
(*r*) Non-brittle, non-curl. (*t*) Brittle and curly.

Procedure—Five foot lengths were spliced together in a continuous loop and subjected to the wear of the test machine. To arrive at the total life of the stronger of the two pieces under test, the broken specimen in each case was replaced with a fresh five foot length and this operation repeated until the stronger of the two pieces broke down. The apparatus used is shown in Fig. A and described elsewhere. For the first series of tests, raw stock, *not processed*, was taken. Following are the results.

Effect of Brittleness

Comparing (*m*) and (*r*)

Test No. 1			
	First break	(*m*)	145 times
	Second break	(*m*)	161 times
	Third break	(*r*)	300 times
Test No. 2—Material as in test (1).			
	First break	(*m*)	147 times
	Second break	(*m*)	150 times
	Third Break	(*r*)	322 times

Effect of Curl

Comparing (*s*) and (*r*)

Test No. 1—Test made with arc.

First break	(*s*)	141 times
Second break	(*s*)	120 times
Third break	(*r*)	331 times

Test No. 2—Test made without arc.

First break	(*s*)	119 times
Second break	(*s*)	98 times
Third break	(*r*)	312 times

Specimen (*s*) did not curl but gave a clean fracture with the loop tester.

Effect of Brittleness and Curl

Processed Film

Comparing (*t*) and (*r*)

Test No. 1A

First break	(*t*)	96 times
Second break	(*t*)	124 times
Third break	(*t*)	78 times
Fourth break	(*r*)	368 times

Test No. 2A

First break	(*t*)	94 times
Second break	(*t*)	78 times
Third break	(*t*)	82 times
Fourth break	(*t*)	66 times
Fifth break	(*r*)	332 times

Specimen (*t*) curled considerably and fractured easily in the loop tester.

AVERAGES

Specimen	*No. Trips*	% $r = 100$
(*r*)	363	100
(*m*)	140	39
(*s*)	119	33
(*t*)	88	22

Comparing (*m*) and (*r*)

Test No. 3—For this test *processed* film was used of the same emulsion as for tests (1) and (2).

First break	(*m*)	142 times
Second break	(*m*)	140 times
Third break	(*r*)	404 times

Test No. 4—Check on test (3) using the same material.

First break	(*m*)	153 times
Second break	(*m*)	115 times
Third break	(*m*)	118 times
Fourth break	(*r*)	432 times

Test No. 5—The same as test (4).

First break	(*m*)	140 times
Second break	(*m*)	148 times
Third break	(*m*)	125 times
Fourth break	(*r*)	440 times

Test No. 6—For this test a complete loop of ten feet of (*m*) stock was used.

Break	160 times
Perforations in bad shape	

Test No. 7—For this test a complete loop of (*r*) stock was used.

Break	547 times
Perforations in bad shape	

Specimen (*m*) curled and twisted spirally when a six foot length was suspended in a vertical position, while specimen (*r*) hung quite straight with only very slight tendency to curl toward the film base.

Discussion of Results

Specimen (*r*) in the column of averages represents good quality raw stock according to our present conception and is rated here at 100%. The loss in quality represented in the percentage column for the other specimens is a defect from whatever cause, irrespective of the source from which the sample was obtained. It may be taken for granted that any of the defects mentioned will give practically the same results as noted, if present in film of the quality of specimen (*r*). Brittleness and curl or both may result from improper methods in processing and is not necessarily inherent in the product. The relative projection strength of these specimens show the extent of damage which may be done to good film and what is to be expected from film having inherently the faults indicated.

During the making of hundreds of wear and tear tests, it was noted that there was always two kinds of noise in the intermittent sprocket mechanism when two pieces of film were spliced together for comparative testing; a hard metalic sound and a rather soft muffled sound. The hard metallic sound was always heard when the longest lived film was passing through the gate. This led to the suspicion that the soft muffled sound was due to yield or flexing of the edge taking the blow of the sprocket tooth. This observation was subsequently confirmed in examining closely the condition of perforations at different stages of the tests and by the "feel" of the perforations as they passed between the fingers in running. The piece giving the soft sound always burred definitely. The perforation edges had become slightly curved.

Summary

Attention has been called to the several physical properties of nitrocellulose film and especially focused upon the yield value as deserving of special study.

The relations which are found to exist between yield and break and yield and temperature, the apparent analogy of the plasticity of nitrocellulose film and the viscosity of its solutions, the dependence of the tensile strength value or break point upon the true record of elongation and the effect of nicks, scratches and rough edges, all appear to serve as points of interest and to invite further study and investigation.

Mention may have been made of the effect of different times in applying a given load but has been purposely avoided as an unnecessary intrusion.

The effects of faults, such as curl and brittleness, already well known, have been reduced to some approximate value and it has been shown how the gelatin functions in promoting the projection strength of motion picture film. Coincident with this, it is clearly demonstrated that the thinning out of the gelatin coating, from friction in the projector or failure to properly wax the perforated edges, very materially reduces the useful life of motion picture film.

The projection strength of film of different thicknesses is discussed. All other things being equal, it appears that .001 inch added to the present standard thickness of film base would materially increase the projection strength of the finished product.

From the suggested curve, thickness against percent strength, (plate 6) it seems that the present standard thickness of around .005 for uncoated film is as thin as it can be safely made, for it is shown that within three or four ten thousandths inch less, the projection strength falls so rapidly as to be practically useless for present day service. It is made clear that between .0048 and .0052, the difference in projection strength is not very marked, the advantage beginning with the sharp rise in the curve at about thickness .0054 and increasing rapidly with increasing thickness from this point.

Conclusion

The day cannot be so far off when material of a more permanent character will replace the present nitrocellulose film base. The march of progress is contemporary with recording and preserving accumulated knowledge. The printed word conveys ideas, stirs the imagination and stimulates conceptions of the thoughts of men.

The record of civilization in Literature, in Art, in Science and in Music—each has its intrinsic worth. Nothing, however, approaches in historic and educational value the records possible with animated pictures.

What a power lies in our hands to trap world progress and pass it on, a thing pulsing and throbbing with life and interest, a record in motion Photography such as no other record can give.

Dimly we can sense the thrill, were we today able to view upon the screen the stirring events of past centuries, to say nothing of the vast virgin field open to educational possibilities, through motion pictures in the present.

DISCUSSION

Mr. Richardson: You state as I understand the matter that the increase to a little over five-thousandths in thickness gives 60% greater wearing qualities; is that right?

Mr. Briefer: If we add one-thousandth to standard film thickness, we find an increase of projection strength from 45% to 100%.

Mr. Theiss: Were the edges in the perforated area lubricated or waxed?

Mr. John G. Jones: Did I understand the elongation on the chart was 30%?

Mr. Richardson: Is there anything in the paper which would give us data on the effect of temperature such as the film is exposed to on the breakdown?

Mr. Holman: Are there any tests showing the relation between breakdown and speed of projection?

Mr. John G. Jones: Was moisture content taken into consideration?

Mr. Briefer: Replying to the question by Mr. Theiss: we did not wax the film, but a section of the paper points to the importance of waxing, as well as of regulating the friction of the gate of the projection machine, in order to avoid thinning out the gelatin at the perforated edges. Had we waxed the film, a variable would have been introduced. Machine conditions were carefully adjusted between tests. Altogether there were eight hundred or nine hundred projection tests made and only a few are recorded here.

In answer to Mr. Jones: the Serigraph gives the elongation for average cinematograph film base as about 25% to 30%.

Replying to Mr. Richardson, the effect of temperature on projection has not been determined in a practical manner. The work, however, includes a study of the relations existing between yield value and projection strength. The opinion is held that the effect of projection temperature is not as important to the useful life of film as are some of the other factors treated in this paper.

To Mr. Holman's question, we will say that the effect of different speeds on break has not been determined. It would be interesting, however, to note what such a test would develop and I suggest that the work be done by someone having the facilities for such an experiment.

Temperature and humidity are recorded where it seemed desirable to do so; these are given in the tabulations. It is our intention to continue work on these problems and include the different phases which have been touched upon in this discussion.

PANORAMIC MOTION PICTURES

By Giovanni C. Ziliotto

THERE are in the presentation of motion pictures, today, defects that can not be denied by people connected with the industry, although they are not always apparent to the general public, or at least are considered unavoidable and therefore accepted without criticism.

The reason for this is that we have become so accustomed to the makeshifts and the shortcomings of the present methods of presentation of motion pictures that we are not always aware of their existence, or as I said, think that they are the only means of expression available to the silent drama.

The fitness of the present shape of the motion picture frame certainly is open to criticism, especially when we desire to reproduce large masses of people and need a greater disproportion of width to height than the present frame provides.

But the gravest defect of today's pictures consists, we believe, in the fact that, since close-ups and cuts were introduced in the filming of motion pictures, the dimensions and proportions of objects and characters are continually changed in order to show, in the largest scale possible, the elements which, in the unfolding of the story, happen to be of most importance.

Due to the relatively small angle included by an ordinary camera it is now impossible to show characters or objects in the largest scale without singling them out from the scene of which they are a part, and which has to be shown before or after in a smaller scale.

In fact, when we wish to reproduce a character in a large scale, we place the camera as close to it as we think advisable; the view of the background showing in the picture will then depend entirely on the optical angle included by the camera. The greater the angle and α the greater the portion of background shown in the picture, so that by using a panoramic camera including a large angle, we can obtain a picture showing us the character in close-up dimensions and showing at the same time a complete view of the scene.

This is what prompted Mr. Alberini, who together with Edison, Lumière and Pathé, was a pioneer in the field of the motion picture industry, to study the proper means to avoid at least some of the worst defects of today's presentation of motion pictures. As a result he has invented the panoramic motion picture camera and developed a practical method for projecting panoramic motion pictures on a screen of standard size, using a standard projector.

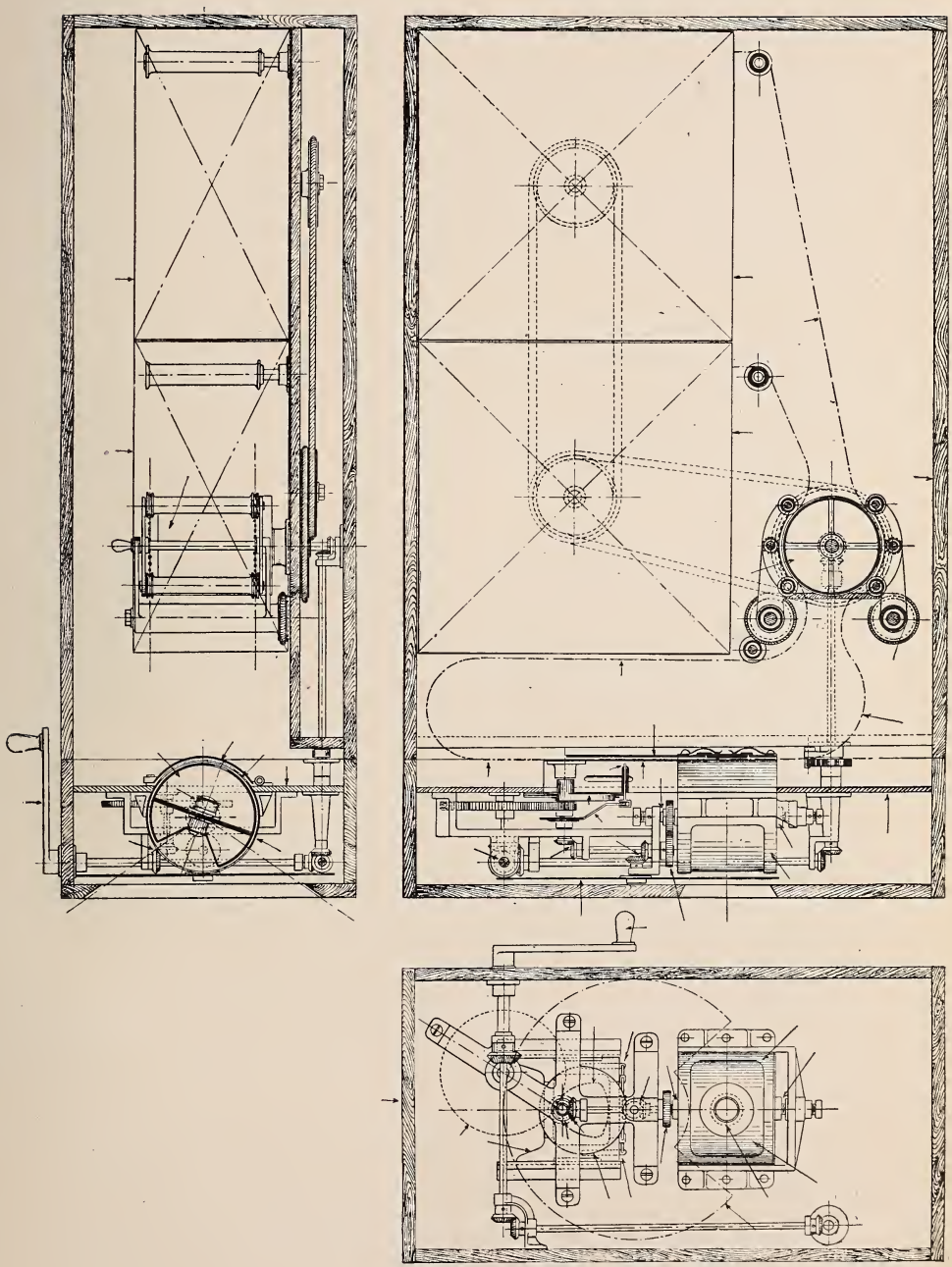


FIG. 1

In the Alberini camera the objective lens, which is carried by a drum, revolves around a vertical axis while the picture is being taken, the film passing in a curved shape in front of the objective.

The film gate and the aperture plate, instead of being plane, are in the form of a segment of a circle around the center of which the objective pivots, see Fig. 1. The radius of curvature is the focal length of the objective. The film moves downward a distance of 24 millimeters to each frame, so that the negative frame is 24 millimeters high. The width of the frame depends on the angle we wish to include and the focal length of the objective: that is we can build cameras that take any desired angle; for each one we will have to use a film of different width, therefore having a different camera for each angle, or we can build a camera using a film so wide as to take care of the widest angle we wish to include; at the smaller angles part of the film will not be impressioned.

For a 65 degree angle and a 35 millimeter focus lens the width is about 40 millimeters, or approximately $1\frac{5}{8}$ inches.

Our negative frame is therefore 24 by 40, instead of the 18 by 24 millimeters used in standard cameras, and includes a vertical angle of about 38 degrees and a horizontal angle of 65 degrees, whereas the same elements for the ordinary camera, having the same objective lens, would be respectively 28 and 38 degrees.

Once we have our negative finished, we print it on a standard positive film by simply scaling down its dimensions by means of a reducing lens. In so doing we cut down the width from 40 to 24 millimeters and the height from 24 to 14.5 millimeters. The size is reduced, but the proportions and the field are the same as in the larger negative.

When we project such a positive on a standard size screen with a standard projector fitted for the ordinary film, we get a frame on the screen the same width as the standard, but of less height, because our frame on the positive film is only 14.5 millimeters, instead of 17.26, as adopted for the standard positive.

Of course we can use a lens in the projector which has greater enlarging power, if we want to have the same height, but in this case the frame will be about 1/5 wider. For instance, if the screen we are now using is $9' \times 12'$, we can obtain a frame $9' \times 12'$ or $7'\ 6'' \times 12'$, or a frame $9' \times 14'\ 5''$, if it is preferred. Which size will be best will depend entirely upon the size and arrangement of the theatre.

The following pictures show shapes and sizes of screen frames which can be obtained by projecting panoramic pictures printed on standard positive film.

a. Represents a picture taken with a standard camera.

b. Represents the same picture taken with the panoramic camera (same objective lens of 35 m/m focal length is used in both cameras).

c. Represents a wider field of the same scene.

All pictures are taken from the same station, but the angle included is respectively: 38-52 and 65 degrees.

d. Is the same as c, that is, it includes an angle of 65 degrees.

e and f. Represent pictures including an angle of 90 degrees.

The pictures on the left side show screen frames obtained using the same projecting lens in the projector.

The pictures on the right side show screen frames obtained either by using a lens of greater enlarging power so as to keep the height of the frame constant irrespective of the height of the positive film

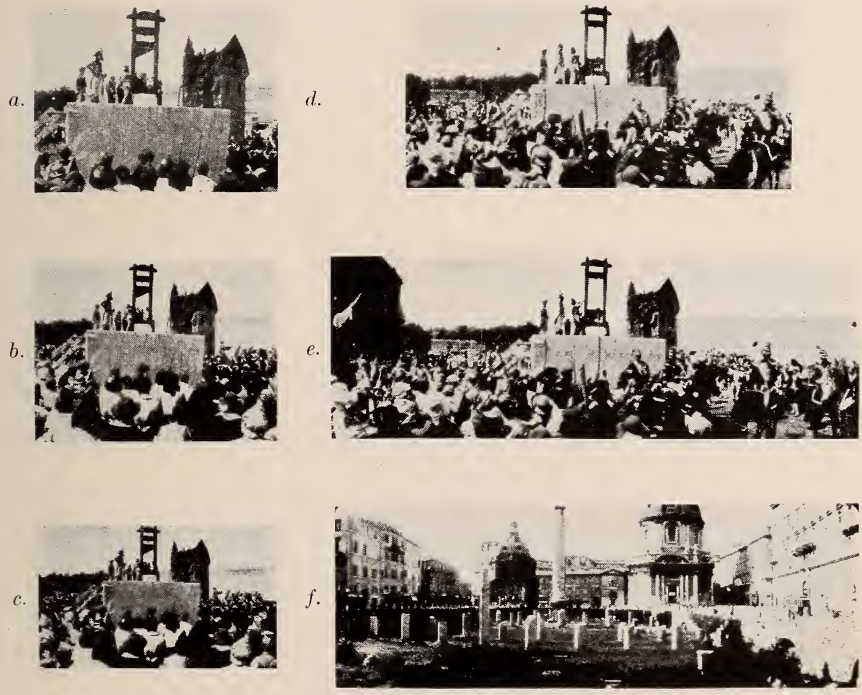


Fig. 2

frame, which becomes less at wider angles, or by using a positive film of the same width as the negative.

Compare relative field covered by matting down any one of the pictures on the right side to the side and shape, although a includes size of frame (a). Note that frame (a) and frame (b) have same 38 degrees, and b 52 degrees.

For large theatres and special productions it may eventually be found convenient to use a special projector, a larger screen and a positive of the same width as the negative. This, however, is a

step to be taken only when the tremendous possibilities of the panoramic principle will have been fully developed.

As I said before, the good features of the panoramic camera are not limited to the possibility of taking pictures of wide scenes from a short distance, but extend to the far greater possibilities inherent in the intrinsic qualities of the panoramic picture.

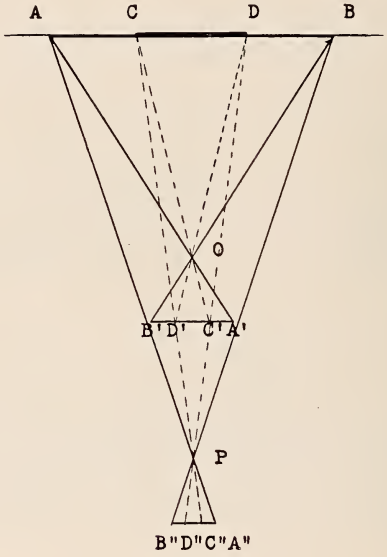


Fig. 3

Let us consider figure 3, in which A-B and C-D are two segments representing one dimension of two objects placed at the same distance from "O" and "P". "O" is the station where we place a panoramic camera including, for instance, an angle of 65 degrees, "P" is the station at which we have to place an ordinary camera, having the same objective, if we want to see both C-D and A-B. The images on the two negatives will be A′-B′, C′-D′ and A″-B″,C″-D″. It is easy to convince ourselves that the two couples of images are proportional, that is they are a reproduction of A-B, C-D in different scales. The only advantage of the panoramic picture is that it is in a larger scale.

But let us now consider figure 4, in which the object of which C-D represents one dimension is placed closer to "O" and "P" than A-B. The images in this second case are no more proportional, as is apparent at a glance. In fact C′-D′ is a larger fraction of A′-B′ than C″-D″ is of A″-B″. In other words by using a panoramic camera we get a picture in which the objects closer to the camera are shown in much larger proportions to those further removed

than would be possible with an ordinary camera covering the same field. Therefore we can have a close-up effect and at the same time allow a wide field as a background.

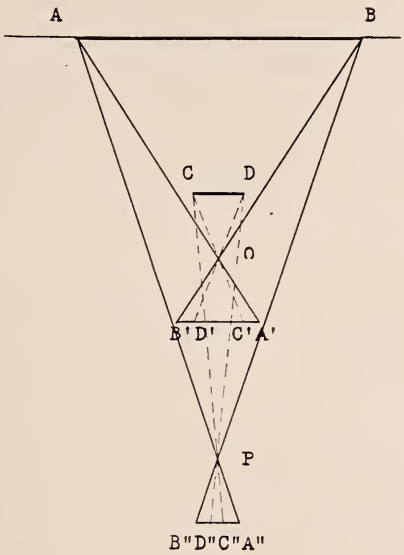


Fig. 4

The fact that we reduce the size of the frame in passing from the negative to the positive has only to do with size, not with proportions and field. Therefore all the gains obtained with the panoramic camera are retained in the standard positive.

Of course, if it is desired to use the theatre screen already in place, our frame on it will be, as we have said, about 15 per cent lower, and therefore the maximum size in which we will be able to project a given object will be about 15 per cent smaller.

I do not think that I need to insist on the advantages of the short distance from which we can take pictures of wide scenes; you have only to think of taking pictures of a baseball game in its entirety from within the grounds, showing in close-up dimensions the most important features and at the same time the general action and the public.

Parades and races: in a word, all outdoor events as well as studio scenes, can be taken with the panoramic camera and have the benefit of its many advantages.

Some have objected that in indoor work the new camera will need larger studios and larger settings. Just the reverse is true: we need smaller studios, as by making them rectangular and utilizing the longer side for the setting and the shorter as the working

distance for the camera we can save in the area covered by the studio. On the other hand we do not need larger settings when they are not desired, because by placing the camera nearer to the scene than would be possible with an ordinary camera, we can limit the field at will. Beside we can always mat the frame down to any width and therefore any desired angle.

Another point that has been raised is the effect of the swinging motion of the objective on the sharpness of the picture, because of reduced time of exposure. This, together with the other objection frequently heard about distortions resulting from the fact that we project a flat positive, whereas the corresponding negative was curved, can best be answered by actually viewing the pictures already taken.

It is but fair to here state that the pictures you will see were taken with the experimental camera that Mr. Alberini himself built, and which I will show you later. I do not want to detract from the mechanical skill and ingenuity of Mr. Alberini, but, as a mechanical engineer, I have to say that many features can be improved upon.

Mr. Alberini has used an asymmetrical objective lens because a symmetrical one of 35 millimeter focal length was not to be found in the market. As the drum which carries the objective has a continuous and uniform rotating motion, and as we can only take a picture for each revolution on account of the objective being asymmetrical, we had to provide for a shutter to intercept the light during one half of the revolution.

I am assured that a symmetrical lens of 35 millimeter focal length covering the height of our negative frame and having a speed comparable to that of an asymmetrical lens can be built. In this case both ends of the objective will become "business" ends and two pictures will be taken for each revolution, cutting down the speed of rotation of the drum by half.

I do not claim to offer to the Motion Picture Industry the last word in the technique of panoramic motion pictures, but believe that Mr. Alberini has started in the right direction towards the goal for better pictures.

As for the projecting side of the new system, I want to make it clear that no trouble will be experienced on account of the frame having less height. Instead of a frame line the positive will have an opaque space below and above the frame so that it will not show on the screen and this screen can be used for projecting the ordinary positive film. I want also to make it clear that the height of the panoramic positive frame depends entirely on the angle it is desired to include. The greater the angle the less the height of the frame, because, no matter how wide the negative is, its width has always to be reduced by photographic process to the standard width of the positive frame, and the height will be reduced proportionately.

In passing, it may be of interest to note that, if in printing we reduce the dimensions so that we obtain a positive frame of the standard height which would therefore fill the standard screen, we still retain a panoramic effect, since we include an angle of about 52 degrees instead of an angle of 38 degrees, as with an ordinary camera having a 35 millimeter focus lens. This is due to the fact that our negative is 24 millimeters high instead of 18, and, in reducing it to this last figure we bring in the standard width a greater field.

We do not want to suggest any particular proportion for the frame, but only to state that, in our opinion, the present shape of the frame is not the best, as we naturally need a much wider vision horizontally than vertically.

I think I owe the members of this Society a word of explanation about the other machines used in connection with the system; these are the printing machine and the perforating machine.

The printing machine is composed of two mechanisms, one taking care of the negative and one of the positive. The negative film moves downward 5 holes at a time (remember that our negative frame is 24 millimeters high instead of 18) while the positive moves upward 4 holes. The inverted motion is necessary on account of the reducing lens interposed between the negative and the positive.

This machine was also built by Mr. Alberini and works well, although made with parts of various machines put together in a very temporary way.

The perforating machine is identical with the ordinary one, only it must be made to accommodate the wider film.

Neither of these machines is used directly by producers, but almost exclusively by motion picture laboratories and film manufacturers, so that few machines are really necessary.

I hope that I have succeeded in bringing to your attention the most prominent features of the panoramic motion picture system invented by Mr. Alberini.

I have devoted considerable time to the preparation of this paper and trust your body will find the matter of interest.

We shall welcome discussion and helpful comment by the distinguished engineers here present.

New York, May 12, 1924

DISCUSSION

MR. RICHARDSON: I did not believe in the wide picture before I saw the camera but he told me that he had a camera giving the effect of width, and I was rather astonished when I saw it. I notice that the picture, while it was the standard width, appeared wider. I was very much impressed, and I got things under way to bring it up here because I was sure it would be interesting to all of you. I think he found a means for giving us the benefit of a wider view with the present screen.

MR. BROWN: I should like to ask Mr. Ziliotto whether he does not feel that straight line architecture or sets in the background are thrown askew by his camera and tends to go off in vanishing perspective at the extreme right and left so that the camera is limited to masses such as crowds or forests, which do not include easily recognized vanishing lines of perspective.

MR. BASSETT: I should like to ask whether it takes any more illumination to obtain a given negative and if so how much more it takes.

MR. HOLMAN: Did anybody notice any effect of relief or plasticity such as Dr. Kellner mentioned? The fact that the lens is swinging about, it means that the rays are superimposed and I think what is lack of definition was due to the swinging action of the lens.

MR. JOHN G. JONES: Can the film be kept in the curved path without scratching when moving through the gates?

MR. ZILIOTTO: These are all very old pictures taken many years ago in Italy and were subjected to extensive handling but as far as I know no trouble was experienced at the gate on account of the curvature of the film.

With regard to the first remark, distortions are bound to take place if you use a 90° or 100° angle but if you limit the angle to 65°, they can easily be eliminated or rendered inconspicuous. I showed the pictures to illustrate the results. Any one can judge for himself. I have shown practically everything from studio scenes to masses, straight line buildings, and so on.

With regard to illumination of the scene, speed of rotation has something to do with the light required. When you take outdoor scenes the light is plenty. If we can get a symmetrical objective, it will have to turn only eight times a second instead of 16, so that there will be required less light than at present. Other improvements can be brought on the present camera with reference to this question. Answering Mr. Holman: This is an entirely different case from that of the camera which takes pictures from different angles. The fact that the objective turns has nothing to do with the taking of pictures from different angles. The panoramic image is still and unique at any angle of the objective.

"CONSTANT CURRENT AND CONSTANT POTENTIAL GENERATORS FOR MOTION PICTURE PROJECTION"

By A. M. Candy

THE projectionist in the booth of a modern motion picture theatre usually has numerous duties to perform—among which the most important is that of maintaining a uniformly well lighted picture on the screen. This can only be accomplished and the effect on the screen will be an exact reproduction of the origina

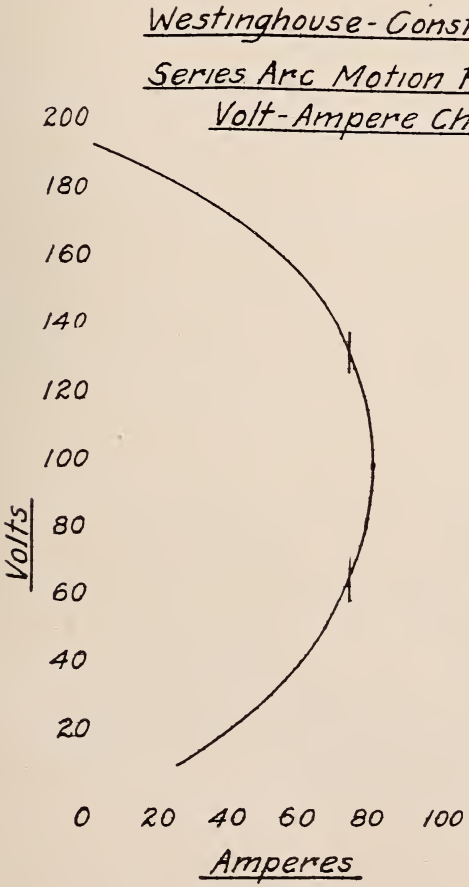


Fig. 1.

scene only if the light source in the lamp house operates at a constant value.

To produce uniform light emission from the carbon electrodes of an arc lamp, it is necessary to maintain a constant rate of direct current flow through the arc. As the carbons burn away at the ends, the gap between them gradually increases which requires a proportionally increasing impressed voltage to sustain the same arc current. Obviously, therefore, if the electrical equipment is designed so that as the arc current decreases when the arc gap and voltage increases, it will be necessary for the operator to readjust his carbon frequently to keep the conditions appreciably constant. It is apparent therefore that if the generator supplying power for the arc is designed so that it will deliver practically a constant current over a wide range of voltage, then the carbons need only be adjusted sufficiently frequently to keep the corners of the picture from becoming discolored.

The volt ampere characteristic of such a generator is shown by Fig. 1. In this case the machine is designed to develop about 65 to 67 volts at 75 amperes and also 130 to 134 volts at the same current value, so that two projection lamps may be operated in series during the transition period and each lamp will receive the same current. At the end of the transition period the operator turns the adjusting knob until the carbons touch in the projection machine which is to be discontinued and then closes a switch which short circuits this lamp entirely. By this scheme of operation the current through the arc being used remains practically constant and the picture uniformly illuminated at all times.

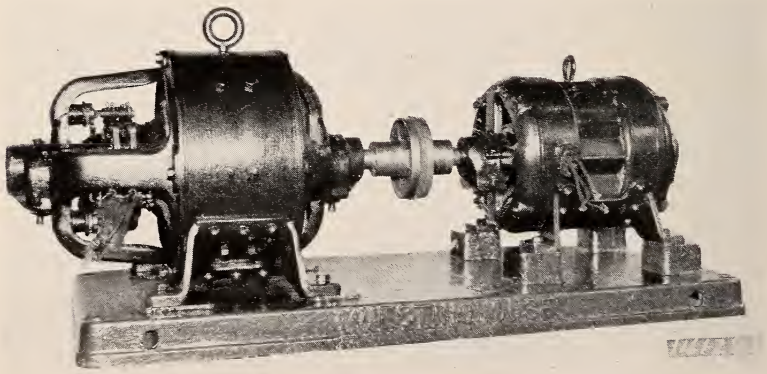


Fig. 2

Fig. 2 illustrates a motor generator built for this service. By especially designing the magnetic circuit of the generator we can prevent the open circuit voltage from rising above the value in-

dicated by Fig. 1, which is not sufficiently high to damage the shunt field windings and, therefore, eliminates the use of a relay to limit the open circuit voltage.

The current values delivered by the machine can be varied from 60 amperes to 75 amperes by changing the setting of the generator field rheostat. The position of the brushes and commutating poles remains fixed at all times so that perfect commutation at all loads is assured.

The only control equipment required for such an installation is a starter for the motor; a small panel mounting an ammeter, voltmeter and field rheostat for the generator, and two single pole enclosed knife switches, one to be mounted on each projection machine for short circuiting the arc. A complete schematic diagram including emergency service is shown by Fig. 3.

For installations where no more than two projection arcs of the same current value are to be operated at one time, this equipment is indisputably the most satisfactory to use and the least expensive to install and operate.

It is not practical, however, to design generators of this type for the operation of more than two arcs in series on account of the high operating voltage and abnormally high open circuit voltage involved.

A great many theatres especially those on the west coast require several projection and other arcs in operation at one time, such as a motion picture projector, a stereopticon and a spot or flood light. For such an installation the constant potential parallel arc machine is best suited.

It is not necessary to go into a detailed description of this equipment as it was described fully by the author in Vol. IV of the S. M. P. E. proceedings. The schematic diagram of connections is shown by Fig. 4 which is sufficient to show wherein it differs from the constant current equipment. When the constant potential equipment is used each arc has a ballast or stabilizing resistance in its circuit and the various arc circuits are connected in parallel to the generator. Therefore, when such an equipment is used the only limitation to the number of arcs which can be operated at one time is the ampere capacity of the generator.

Summary

To summarize briefly, we find that where not more than two projection arcs of the same current value are to be operated at one time, the constant current series arc equipment is best suited on account of its simplicity, good operating characteristics and improved operating efficiency. When more than two arcs are to be operated at one time at the same or different current values, the constant potential multiple arc equipment is less expensive and more satisfactory relative to general operating conditions.

General Engineering Dept.
Westinghouse Electric and Mfg. Co.

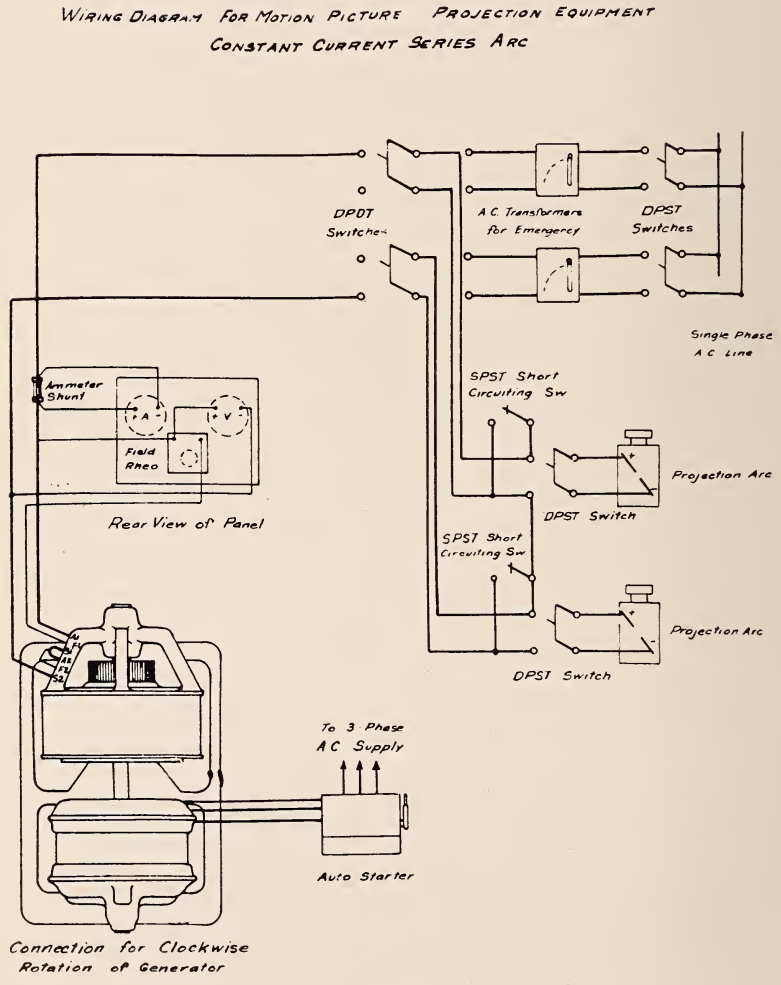

WIRING DIAGRAM FOR MOTION PICTURE PROJECTION EQUIPMENT
CONSTANT CURRENT SERIES ARC
DPDT Switches
A.C. Transformers for Emergency
DPST Switches
Single Phase A.C. Line
Ammeter Shunt
Field Rheo
Rear View of Panel
SPST Short Circuiting Sw
Projection Arc
DPST Switch
SPST Short Circuiting Sw
Projection Arc
DPST Switch
To 3 Phase A.C. Supply
Auto Starter
Connection for Clockwise Rotation of Generator

FIG 3

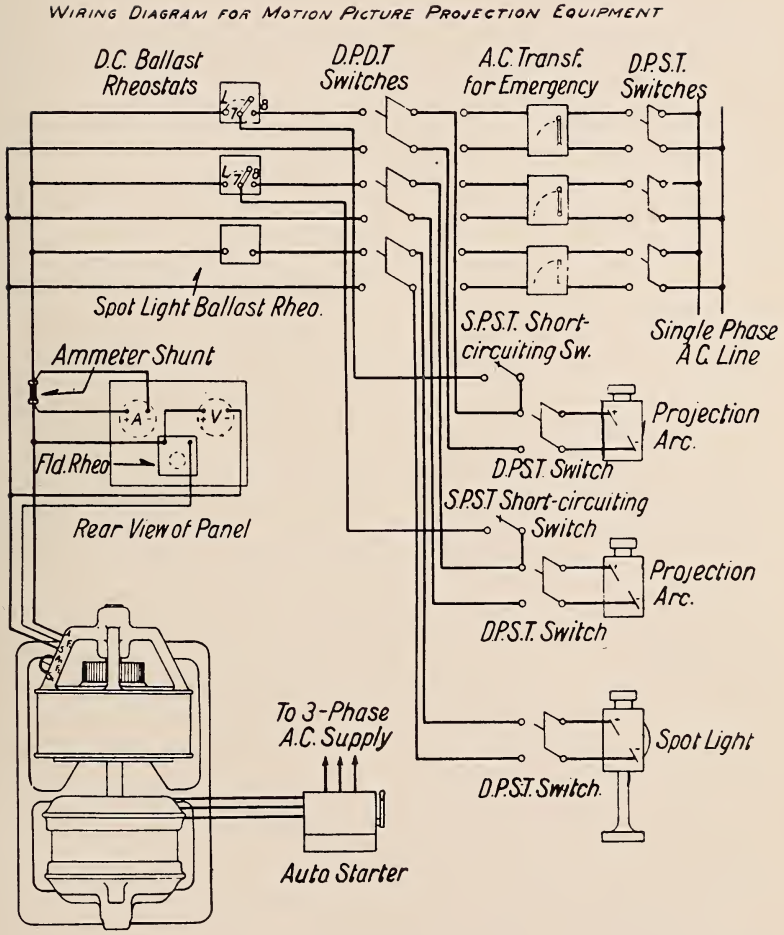

WIRING DIAGRAM FOR MOTION PICTURE PROJECTION EQUIPMENT
D.C. Ballast Rheostats
D.P.D.T Switches
A.C. Transf. for Emergency
D.P.S.T. Switches
Spot Light Ballast Rheo.
Ammeter Shunt
Fld. Rheo
Rear View of Panel
S.P.S.T. Short-circuiting Sw.
Single Phase A.C. Line
Projection Arc.
D.P.S.T. Switch
S.P.S.T. Short-circuiting Switch
Projection Arc.
D.P.S.T. Switch
To 3-Phase A.C. Supply
Spot Light
D.P.S.T. Switch.
Auto Starter

FIG. 4

DISCUSSION

MR. RICHARDSON: First I should like to ask as one member of the Nomenclature Committee that the writer change his nomenclature to accord with that of the Society. We are hardly consistent when we publish one thing one way and something else the other. I should like to know what the efficiency is of this set both with 2 arcs and with one arc in operation.

MR. CANDY: When operating one arc the efficiency is about 70% and operating two arcs it is about 75%.

MR. BOWEN: Has Mr. Candy had experience with the series type of generator in connection with the high intensity lamps?

MR. CANDY: I don't think any of our machines have been app'ied for use with high intensity lamps; I do not see why they should not be satisfactory with one possible exception and that is the high intensity lamp has a feed motor operating off the arc voltage, and if the arc was extinguished in the lamp it would receive line voltage and it might damage the motor; however, that can probably be obviated by the use of relays which would keep the machine shorted when no arc was in operation. It is good practice to operate the machine short circuited under this condition because it saves it from developing a high voltage and our experience has shown it is well to keep both shorting switches closed when neither are in operation. That is the best answer I can think of off-hand.

MR. RICHARDSON: I think Mr. Bowen or Mr. Griffin should set forth, in order that it may get into our TRANSACTIONS, the difficulties encountered with the generator when used with a high intensity lamp. I think they are more familiar with the matter than I am.

MR. GRIFFIN: I am sorry that Mr. Candy has not data on the application of his Series Type Generator in connection with high intensity arcs because it would improve this discussion considerably. Mr. Bowen asked this question because a tremendous amount of difficulty is experienced with the lamps, when used in connection with series arc generators. The General Electric Company's set functions very well on the orinary arc, and I believe the maximum numbers of sets in use are of the G. E. type. I don't think we have had any series type generator which has not given trouble while with the parallel set we have not experienced any trouble nor any difficulty where the direct current is brought into the theater from the service company. I have asked the question many times during the last year and others have asked it and none of us has been able to get any reason as to why the series arc set does not function with a high

intensity lamp. They have blamed it on everybody but the generator people, and they have put in new panels and the trouble starts again the next day. If anybody here has had any experience along that line it would be worth while hearing.

MR. CANDY: What are the symptoms of this?

MR. GRIFFIN: The symptoms are that the current will change from 80 to 100 amperes, fluctuating all the time. That is what I want to have explained. I know the engineering of the set but I don't know why it does it. The voltage doesn't change much.

MR. PALMER: I think I might suggest something that has a bearing on the question. We use high intensity arc lamps for studio illumination and find the same variation in amperage mentioned. It is due to the fact that the carbons burn away rapidly and the length of the arc doesn't remain constant. That is what we attribute it to. The resistance is not constant and the flow of current even if the voltage is constant cannot be regular.

MR. GRIFFIN: This does not answer the question because if you have a constant current supply without change in the lamp and carbons the same condition would be true with any generator. The current reading is solid. It is fine for studio work; it cannot be compared with the picture screen. You don't notice the light fluctuation in the studio, but the smallest amount shows on the screen.

MR. RICHARDSON: I have accumulated the idea for lack of any other that the thing is fundamentally due to variation in the resistance of the arc; why it has such an effect I don't know, but I have been wondering of late if it was not the over-sensitiveness of this type of generator. Mr. Candy should be able to answer this question.

MR. BASSETT: I have had a little experience with the series sets and I agree with Mr. Griffin that satisfactory operation is impossible as the sets stand. This appears to be due to over-sensitiveness of the set. It is possible with a high intensity arc or trim to run two arc conditions, both of which have the same amperage and voltage and yet give different results in arc length and illumination. It is possible, if the generator responds too easily, to cause a disturbing continual fluctuation between a poor flaming condition and an overloaded high intensity condition of the arc. The voltage and amperage of the arc stays almost constant provided the arc length is regulated to keep the voltage constant. If this is not done, the current varies from 80 to 150 amperes.

MR. MAYER: Following this, I should like to ask whether Mr. Candy has attempted to operate this with the same characteristics.

MR. BASSETT: Yes, you do find the same characteristics operating in series unless you anchor the position of one of the arcs; that is, not allow it to feed to arc voltage. It is possible to operate three arcs in series with good results.

MR. TOWNSEND: I thought when Mr. Richardson spoke that

he struck near it when he mentioned the sensitiveness of the generator in the series form. I think that is at the bottom of it.

MR. GRIFFIN: I don't know whether Mr. Bassett understood Mr. Mayer's question.

MR. MAYER: He did, and he answered it correctly,—whether in his experience he had a pair of high intensity arcs with constant potential circuit and whether he found the same phenomenon as with the constant potential machine.

MR. RICHARDSON: I would suppose that the resistance of the high intensity arc is subject to more rapid fluctuation than that of the ordinary arc, though I am not sure it is true.

MR. BASSETT: The resistance does fluctuate in a high intensity arc if you give it a chance because the potential gradient through the negative flame is only about half what the potential gradient is in the gas ball itself. As the crater depth changes it will change the length of the arc and affect the arc voltage.

MR. CANDY: The sensitivity of the generator—I don't know exactly what is meant by sensitivity; what I would construe it to mean is that the generator voltage rises very rapidly without change of current. With the constant potential equipment the current has got to change before the voltage will change very much because you have a ballast rheostat in series with the arc, and if the current decreases, the voltage applied to the arc increases but you must have a decrease in current to get an increase in arc voltage whereas with the series arc type machine the voltage will change without change in current, and in that sense it is more sensitive.

I think the points on high intensity arc characteristics are at the bottom of it. It looks as though the machine should be designed for high voltage operating at about 70 volts where the ordinary low intensity arc operates at about 65 or below so that it may be the series type of machine must be operated at higher voltage, but if there is instability in the arc it may be a problem to get the solution.

THE MAKING OF MOTION PICTURE TITLES

By J. I. Crabtree

Communication No. 207 from the Research Laboratory of the Eastman Kodak Company.

A MOTION picture title may be defined as the reading matter interspersed between the scenes in order to assist in a better understanding of the picture. As a result of refinements in scenario writing, and in acting, the modern photoplay requires less verbal description than formerly, the tendency being to make the picture "speak for itself" as far as possible. This cutting down of the quantity of title matter has resulted, however, in a marked improvement in quality, especially in the direction of more artistic lettering and the addition of suitable backgrounds, especially in color.

The Nature of a Title

Title matter as seen on the screen usually consists of white lettering on a more or less dark background. Black letters on a white background are rarely seen. The dark background gives increased visibility of the lettering with a minimum of eyestrain and prevents a sudden change in screen brightness which would result if a white background title succeeded a dark interior scene. In this connection there is a growing tendency to eliminate the extremely contrasty titles formerly in vogue by the use of backgrounds of lighter density so that the screen brightness more nearly approaches the integrated screen brightness existing with the average scene.

Classification of Titles

Titles may be classified as follows:

1. Uniform background titles
2. Illustrated background titles
3. Titles with relief lettering with either plain or illustrated background.
4. Scroll titles having either uniform or illustrated backgrounds with or without relief lettering.
5. Animated titles.

I. Uniform Background Titles

A motion picture title is made by photographing the copy by means of reflected or transmitted light. The copy may consist either of printed matter or hand lettering on an opaque or translucent support. The lettering may be either black on a white or translucent ground or vice versa according as a direct positive for insertion in

the positive print, or a negative (indirect title) for insertion in the negative proper is required.

Direct and Indirect Titles

A direct title is one which is made directly on positive film by photographing either black lettering on a white card by reflected light or black lettering on a transparent support by transmitted light. If only a few copies are to be made it is more economical to make direct titles because the necessity of making an intermediate negative is eliminated, although insertion of positive titles in the positive print introduces an abnormal number of splices. If a number of copies are desired or if a minimum number of splices are required in the print then it is necessary to make a negative title which is inserted in the negative proper before printing.

When making direct titles on positive film it is necessary to photograph through the base; that is, the base side of the film should face the lens. This reversal of the film in the camera gate is unnecessary if a reversing prism is used before the lens or if transparencies are copied, since these can be reversed before the illuminator. When photographing through the base of the film the image lies chiefly in the underlayers of the emulsion so that development of the image is somewhat retarded and it is not possible to secure quite as much contrast under given conditions as when photographing directly on the surface of the emulsion, although this difference is not of great practical importance.

In case positive film with tinted base is used for making direct titles by photographing through the film base, the screening effect of the colored base must be compensated for by a proportionate increase in exposure. The relative exposure necessary under identical conditions with the various Eastman tinted bases is as follows:

Nature of Tinted Base	*Relative Exposure*
Ordinary Positive	1
Red	Very Great
Pink	1.75
Orange	4.0
Amber	7.0
Yellow	8.0
Blue	1.0

When using a reversing prism or when photographing the copy by transmitted light, variation of the exposure with the different bases is, of course, unnecessary.

Reflected and Transmitted Titles

The advantages of making titles by transmitted light as against reflected light may be tabulated as follows:

1. It is possible to secure greater contrast when photographing by transmitted than by reflected light for the following reason.

The whitest paper obtainable reflects only about 70% of the incident light while the blackest ink reflects about 2%, so that the contrast between the background and the lettering is 1 to 35.

In the case of a transparency consisting of clear lettering on a background having a photographic density of 2.0 which transmits one-hundredth part of the incident light, the contrast is about 1-100 or nearly three times that of the best result obtainable by reflected light. Although it is seldom necessary to secure maximum contrast, in choosing between two methods of working the one capable of giving the most contrast should be chosen.

2. The tendency of the lettering to veil over is a minimum. An average title has a background density of 1.5 to 2.0, but when making direct positive titles by reflected light, especially if the lettering is small, the letters "fill-in" or become veiled if sufficient exposure is given to secure a background density of this order. For making direct positive titles the transmitted light method is strongly recommended, because it is capable of giving high contrast with comparative ease.

3. Compound and background titles are readily made by superimposing two transparencies without the necessity of double exposure as is the case with reflected titles.

4. When making direct positive titles on tinted base it is possible to photograph on to the emulsion surface without employing a prism by reversing the transparency before the illuminator.

Since it is often necessary to prepare titles from white card copy submitted it is desirable that the title making apparatus should be adapted for photographing either by reflected or transmitted light.

The Copy

The reading matter to be photographed may be set up in various ways as follows:

1. By arranging black or white letters cut out of metal, cardboard, celluloid, etc., in parallel grooves on a board or other support.

An ingenious method of preventing easy displacement of the letters is by using magnetized metallic letters on a metal support. Titles composed in this manner cannot be conveniently filed away, but must be reset if a retake is necessary after a prolonged interval.

2. A modification of method I is employed by one of the largest title making concerns.[1] Individual letters (black letters on a white background) are photographed on to small rectangular sheets of film and the copy is then set up by fitting the sheet film letters in grooves in a frame which is then photographed by transmitted light. The film letters in the frame (white letters on black background) are allowed to overlap slightly so as to obliterate the lines of contact. Negative titles are, therefore, made directly by a single

[1] "Titling Simplified," Exhibitors Herald, May 24, 1924, p. 49.

copying. This method has the additional advantages that any size of specially designed lettering is readily secured by simply copying the artist's drawing; photographic copy may be inserted in the frame in place of part of the lettering; while the pressman's labor involved in the operation of printing the usual title card is eliminated.

3. By hand lettering.

4. By printing either with hand-set or machine-set type on paper or card. Black letters on a white ground are required for direct titles and white letters on a black ground for negative titles. Aluminum bronze or silver leaf is often used in place of white ink.

An alternative method of securing white letters on a black background is to print with black lettering on a translucent support, such as tissue paper or oiled paper; then use this as a negative and make a photographic print on glossy paper. By using a contrasty paper and fully developing the grain of the paper negative may be largely eliminated.

Type matter may also be set up on a "multigraph" machine consisting of a cylindrical drum fitted with grooves on the periphery. The type matter is first assembled on a "pencil" and then transferred to the grooves on the drum.

5. By printing as in No. 4 on a transparent support, such as film base, waxed paper, etc. In order to determine the best medium and the relative effect secured with different media the following experiments were made.

Using the various supports outlined below increasing exposures were given with each support and the resulting exposures developed for a constant time. The title was then selected which just showed signs of "filling-in." This represented the most contrasty title which it was possible to make with the particular support. The density of the background was then measured. The results obtained were as follows:

Nature of Support	*Background Density*	*Remarks*
Tissue Paper	1.18	grainy
Onion Skin Paper	1.44	"
Oiled Tissue Paper	1.48	"
Oiled Onion Skin Paper	1.50	"
Tracing Cloth	1.20	Pattern of cloth reproduced.
Film Support with dusted letters	1.66	
White paper (reflected light)	1.33	

From the table it is seen that dusted lettering on film support gives the most contrast and this method of preparing transparent titles is recommended. The "film title cards" are prepared by

printing with "celluloid ink" (a quick drying ink of special consistency) on to Kodaloid and while the ink is still wet, very fine carbon black is brushed over with a fine camel hair brush. When the ink is thoroughly dry the excess lamp black is brushed off and, if necessary, the residual traces are removed by brushing with a soft piece of plush. Very great care in printing is necessary to secure satisfactory impressions on celluloid. Titles on oiled onion skin paper are more easily prepared and give satisfactory results providing the slight resulting graininess of the background is not objectionable. Printed matter on waxed or oiled union skin paper may be dusted with carbon black in the above manner in order to increase the opacity of the lettering although it is not always possible to thoroughly remove the excess black without smearing the clear paper.

Size of Copy and Nature of Type

For the sake of economy the title card should not be too large although an 8×10 card with the printed matter fitted in an area 6″×4¼″ is convenient. The typesetter should should always keep within a rectangle, whose sides are in the proportion of 4:3. The modern tendency is to eliminate borders of any description.

In case the titles are set up in type, the selection of a suitable type face is a matter for careful consideration. It should preferably be bold in order to lessen the tendency of the letters to "fill-in." Suitable type faces are Souvenir, Cheltenham Bold, Rugged Roman, Kennerly, Packard, and Cloister Italic supplied by the American Type Founders Association. Many producers employ type specially designed to suit their individual requirements. A selection of 18 to 36 point type, upper and lower case, is sufficient for most purposes.

Typesetting is an art in itself and does not come within the scope of this article.[2]

Title Making Apparatus

An apparatus for making titles consists essentially of a track supporting a camera and easel which in turn holds the title card. The fundamental requirements are that the title card should be adjustable both vertically, horizontally, and by rotating in a vertical plane, while the distance between the camera and easel should be variable so as to accommodate cards of different sizes. The best arrangement is one which permits of moving the camera on a bed in the direction of the easel, while all other adjustments should be attached to the easel. A simple and efficient bench consists of two parallel concrete walls about 4′ 6″ high, along the top of which iron runners are fitted, while the camera carriage is bridged across

[2] "Typography of the Movies" by E. G. Gress, The American Printer, 65:25 (1917).

the walls. Details for constructing a fully adjustable easel are given by the author and C. E. Ives.[3]

The Camera Requirements

Only the best cameras should be employed. Dowelling pins are indispensable in order to insure registration in double exposure work. The gate tension should be adjusted so as to accommodate the thinner positive stock, while reflections from the usual strip of steel on the pressure plate in the gate which often cause a dark line through the center of the film should be prevented by replacing he steel with a strip of ebony. The frame line should be capable of adjustment through a distance of one full pitch in order that titles may be matched to negatives which do not have the standard frame line midway between perforations. The gate aperture should be made considerably larger than the standard projector gate in order to prevent the possibility of a border showing on projection.

A series of lenses of 2, 3, and 4½ inches focal length fitted in focussing mounts is desirable. The camera should be motor driven and fitted with a reversing switch and counter for making dissolves.

The Lens Hood

A lens hood is an essential camera accessory if maximum photographic contrast is required. The hood functions by eliminating flare due to extraneous light. An ideal lens hood is one having a rectangular aperture, the length of the sides of the aperture having a ratio of 4:3, which is the ratio of the length to the breadth of the camera gate. If the lens were a pin hole then the aperture of the lens hood would be in focus no matter what its distance was from the lens, but in the case of an ordinary lens, unless the aperture is placed at a considerable distance in front of the lens when the latter is focussed at infinity, the image of the aperture is not sharp; that is, there is a vignetting effect at the gate. It is obvious that the aperture of the lens hood should be sufficiently large so as not to vignette, but the greater the extent of the vignetting the greater the size of the aperture must be over and above that required for an ideal lens (a pin hole), although the efficiency of the lens hood is then proportionately less. For a circular lens hood the following formula gives the relation between the diameter and the length.

$$\text{Diameter of Hood} = \frac{5}{4} \times \frac{\text{Length of Hood}}{\text{Focal Length of Lens}} + \text{Aperture of Lens.}$$

The width of the lens aperture is found by dividing the focal length by the F number of the lens; that is, for a 2″ lens working at f/4 the width of the aperture is one-half inch.

[3] "Improvements in Motion Picture Laboratory Apparatus," This Journal No. 18, 1924.

As an example, to find the width of a hood 8″ long for a lens having a focal length of 2″ and working at f/4. Width of hood $= \frac{5}{4} \times \frac{8}{2} + 1\frac{1}{2} = 5\frac{1}{2}$″. This gives a cylindrical hood $5\frac{1}{2}$″ in diameter having a length of 8″, which should be fitted with a rectangular opening as large as possible.

The same result could, of course, have been obtained by trial and error, by viewing the gate image while varying the hood aperture and observing when a vignetting occurred.

Since the longest hood is the most efficient, the most satisfactory hood for title work consists of a black mask having a rectangular opening (ratio of sides 4×3) placed between the illuminating lamps and the camera. The opening may be made adjustable by means of suitable sliding shutters in case different sized title cards or different lenses are used. The correct size of the opening may be found either by trial and error or by calculation as above.

The Lighting Equipment

Of the three available light sources, namely, arc, nitrogen tungsten, and mercury vapor, the latter is to be preferred on account of the greater photographic actinic power of the radiation, its adaptability for uniformly illuminating large areas, and the fact that the intensity fluctuation with voltage is not of the same high order as with tungsten lamps. The "M" type of mercury tube is to be preferred, while there is little to choose between lamps for AC and DC current. For making titles by transmitted light a sheet of opal glass arranged in a frame in front of the "M" tube lamp constitutes a very uniform source of illumination.

Choice of Film Emulsions

Since positive film emulsion is capable of giving greater contrast than negative emulsions, positive film is usually employed for making every type of title, both direct and indirect, although when making the negative for indirect titles sufficient contrast may be secured on negative film, which has the additional advantage that it does not have as great a propensity as positive film to attract dust in the printer, or become scratched in the camera.

Exposure and Development

With a constant light source at a constant distance from the title card, the exposure is controlled by the speed of taking and the lens aperture. A speed of 8 to 16 pictures per second is usually employed but it is desirable to work at the smallest possible lens aperture in order to increase definition. For a given development the exposure should be so adjusted that no spreading of the letters in the case of negative titles or "filling-in" in the case of positive titles occurs. It is customary to fully develop titles in a contrast developer, but care should be taken not to exceed the fogging point. The fogging point of the developer is determined by developing un-

exposed strips of film for increasing times and noticing the time of development at which fog just commences to appear. If a developer fogs in, say, 10 minutes, a safe time of development is 8 minutes providing the developer does not give stain. A suitable developer formula for titles is as follows:

	Metric	*Avoirdupois*
Elon	1.0 gms.	7 ozs.
Sodium sulphite (desiccated)	75.0 "	31 lbs.
Hydroquinone	9.0 "	4 "
Potassium carbonate "	25.0 "	10 "
Potassium Bromide	5.0 "	2¼ "
Water to make	1 "	50 gal.

The average time of development is 7 minutes at 65° F.

The Contrast of Titles

The limiting contrast obtainable, which is measured by the background density providing the lettering remains perfectly clear is determined by the tendency of the letters to become veiled over or fogged, and the extent of the side spreading of the image which is manifested by broadening of the letters in the case of negative titles and "filling-in" of the letters with positive titles.

A simple method of testing titles images is to press the film emulsion face down on to a sheet of white paper. By comparison with a title of good quality any trace of fogging or image spreading is readily discernible.

Veiling of the lettering may be a result of the following causes:

1. Chemical fog due to over-development.

2. Light fog caused by reflection from points outside the title card area. This may be eliminated by blackening the board to which the title card is attached and by the use of a lens hood (see above).

Spreading of the Image may be a result of:

1. Irradiation in the film emulsion or reflection of light from the small crystals of silver halide composing the emulsion. In the case of positive film the extent of this is negligible.

2. Aberrations in the lens system which limit the ability of wide aperture lenses to resolve fine detail. By stopping down the lens these aberrations are diminished so that by using a small aperture lens or a wide aperture lens stopped down spreading of the image is minimized.

Lens aberrations are also of lower magnitude when violet light is used, which is another argument in favor of mercury vapor illumination for title work.

As a result of experiments to determine whether the degree of spreading of the image for a given background density was greater when giving a minimum exposure and developing to the limit or when developing for a shorter time and giving an increased exposure so as to secure the same background density, no difference in the "filling-in" of the letters was observed. Nothing is to be gained,

therefore, by developing to the fogging point. As explained above it is best never to approach the fogging point within two or three minutes.

II. Illustrated Background Titles

An illustrated title consists of lettering superimposed on a picture background which must be in low key so as not to distract the eye from the lettering. The background may be made from an artist's drawing, an enlargement from a single picture frame of the motion picture, or by photographing an actual setting. The procedure for making such titles may be outlined as follows:

1. Illustrated Titles by Reflected Light

A. Direct Titles

Use a negative drawing or photograph of background with superimposed black lettering.

B. Indirect Titles

Make a double exposure first with a positive drawing or photograph and then with a white lettered title on a black ground.

2. Illustrated Titles by Transmitted Light

A. Direct Titles

Use film negative of subject in contact with a second clear film with printed lettering.

B. Indirect Titles

Make a positive transparency from 2-A by contact printing and then copy with the title camera or make both positive and final negative in the title camera.

The photographic quality of the background image is of great importance if a low key effect is to be obtained in the final positive with normal development. It should be fully exposed and very much under-developed. When making illustrated titles by transmitted light an idea of the density of the transparency image at the various stages of the process is given in the following table:

Nature of Film	*Average Maximum Density*	*Degree of Development*
Background Negative	0.7 to 0.9	1 min. No. 16 dev.* 65° F.
Camera Exposure (positive)	1.1	Fully develop
Negative	0.9	2 min. No. 16 dev. 65° F.
Final Positive	2.0	5 min. No. 16 dev. 65° F.

III. Relief Titles

An appearance of relief may be imparted to the letters of a motion picture title by adopting the method employed by sign writers, namely, edging the clear letters with a narrow line having a greater density than the surrounding background so as to give the

*Manufacturers' recommended developer for Eastman Positive film.

effect of a shadow which in turn produces a relief effect. The method of producing the relief effect when making direct and indirect titles by reflected or transmitted light may be outlined as follows:

1. By Reflected Light

A. Direct Titles

Black letters on transparent title card	White letters on gray ground	White letters Black letter shadows, Gray background

Superimpose No. 1 and No. 2 slightly out-of-register and copy with title camera.

B. Indirect Titles

Make negative from No. 3 above or:—

Black letters on transparent title card	White letters on black ground	Dark letters Clear letter shadows, gray ground

First expose card No. 1, then make a double exposure with card No. 2 slightly out-of-register.

2. By Transmitted Light

A. Direct Titles

Black letters on transparent title card	Clear letters on gray ground	White letters Dark letter shadow, gray ground

Superimpose No. 1 and No. 2 out-of-register and copy the composite title.

B. Indirect Titles

Black letters on transparent title card	Clear letters on black ground	Black letters Clear letter shadows, gray ground

First expose No. 1, then make a double exposure with No. 2 slightly out-of-register.

Illustrated relief titles may be made in a similar manner, though the background image should be of low contrast throughout the various steps of the process in order to permit of normal development of the final print.

IV. Scroll Titles

When the quantity of reading matter in a title is too great to be accommodated in one picture frame a scroll is often made. When viewed on the screen the lines of a scroll title move in a vertical direction either continuously or intermittently. The effect is secured by printing the lettering on a long sheet and stretching the sheet between two rollers attached to the easel of the title apparatus. The scroll is then wound on one of the rollers either continuously or intermittently during cranking of the camera. Short scrolls are made by printing on an elongated card arranged between guides on the title card holder and moving the card by hand during the exposure.

V. Animated Titles

Titles in which the letters appear one by one and similar animated efforts are made in the same manner as animated cartoons.[4]

The various methods of securing trick effects are also frequently applicable in making special titles, but this is beyond the scope of the present article.

Troubles

1. *Lack of Definition.* This may be a result either of imperfect focussing or "filling-in" of the lettering. Focussing is facilitated by the use of a magnifier or by removing the film and placing a strip of matted film base in the camera gate. Matte film for focussing is easily made by washing the emulsion from positive film in hot water and then rubbing the film on a smooth surface covered with moistened powdered carborundum.

"Filling-in" is a result of over-exposure or the use of too wide a lens aperture.

2. *"In and Out of Focus Effect" on the Screen.* This is a result either of insufficient gate tension or buckling of the film caused by too rapid drying of the film. Buckle may be prevented by slow drying and taking care that the film is not subjected to tension during drying. Buckled film may often be restored by re-subjecting it to a humid atmosphere.

3. *Fluctuation of Background Density.* This is caused either by unsteady cranking or fluctuation of intensity of the title card illuminator. Mercury vapor lamps should be allowed to burn from ten to fifteen minutes before commencing work in order to attain maximum intensity. Fuctuations in the line voltage should be carefully guarded against.

4. *Camera Static.* This is often a result of excessive tension or friction in the camera. The relative humidity of the title making room should be not less than 60% to 70%. Obstinate cases may be overcome by allowing the film to remain over night in a humidor

[4] "Animated Cartoons" by E. C. Lutz, Scribner's Sons, New York.

though excessive humidification of the film will cause sticking and buckling in the camera.

5. *Unsteadiness on the Screen.* Is a result either of unsteadiness in the camera mechanism or lack of rigidity of the camera support.

6. *Lettering is not Parallel with Frame Line.* Title card was not level during taking. The best method of insuring parallelism of frame line and lettering is to sight along a horizontal straight edge fitted to the top of the camera.

Rochester, N. Y.
June 5, 1924.

DISCUSSION

MR. MAYER: I want to ask Mr. Crabtree why he specified the use of a lens hood on the camera. Is he referring to transmitted or reflected light?

MR. CRABTREE: If the title card is surrounded by a black border there is little necessity for it. Scattered light comes in from the sides and especially if the camera is facing a well lighted portion of the room. The object of the lens hood is simply to cut out as much stray light as possible.

REPORT
OF
STANDARDS AND NOMENCLATURE COMMITTEE

May, 1924.

Introduction

IT WILL be recalled that at last Fall's convention in Ottawa, it was voted to take no action on either the report of the Standards Committee, or that of the Nomenclature Committee, due to the small attendance at the time of presentation of these reports.

Your present Committee has studied these reports very carefully, and combined the recommendations contained therein with additional ones. The entire matter is, therefore, combined into one report, dealing first with Standards and second with Nomenclature, as follows:

Historical

Diligent study of our Transactions reveals the fact that the Society has not yet officially adopted standard dimensions for newly perforated motion picture film. The history of this matter as it appears in our printed Transactions is as follows:

The Standards Committee was first appointed at the Washington Convention, May, 1921.

At the Buffalo Convention, November, 1921, the Standards Committee submitted drawings and dimensions for professional standard film, and also considered the question of submitting these drawings and dimensions to the American Engineering Standards Committee. The Standards Committee report given on page 163 of the No. 13 Buffalo Transactions, reads in part as follows:

First—

The dimensions given in the drawing entitled "Standard Safety Film" are not those published in the transactions of May, 1920, but rather those in apparently universal use at present. According to the constitution, the dimensions of the drawing cannot be formally adopted by the Society as standards before its next meeting, at the very earliest. The Standards Committee cannot approve the submission of standards to other societies, which have not been so adopted.

Second—

The addition of the word "Professional" in the title "Professional Standard Film" has not been authorized by the Society by tentative adoption at one meeting and formal adoptance at a subsequent meeting, as required by the constitution. The Standards Committee

cannot approve the introduction of such limiting terms without such authorization.

The Standards Committee report in the No. 14 Transactions, Boston, 1922, re-submitted drawings of the standard and safety standard film, but with the word "Professional" omitted from the standard film. These drawings and dimensions were approved by the Society, and reported on page 188 of the No. 14 Transactions. The slight change made, however, necessitated the material laying over six months before it could be officially adopted by the Society.

In the No. 15 Transactions, Rochester, October, 1922, the Standards Committee report, page 132, reads in part as follows: Perforated Motion-Picture Film—

The Committee has just learned that the Eastman Kodak Company is now compiling data on the shrinkage of film, and on the dimensions of sprocket models manufactured by the various companies. The results of this, a study far more exhaustive than can be made by the Committee, will be available to the Society, probably by the meeting next Spring. The Committee, therefore, suggests that the Society wait until that time before again considering the standardization of the dimensions of perforated film.

The No. 16 Transactions, Atlantic City, May, 1923, page 308, contain the following portion of the Standards Committee report dealing with newly perforated motion picture film:

"The matter of film perforation has been discussed during the present session in connection with the work of the Committee on Film Perforations, and has been referred back to that Committee for further consideration."

The net result of this is, that the Society has not yet officially adopted the dimensions for newly perforated motion-picture film.

It also appears that whereas the dimensions and cuts referred to above show a film width of the 35 m.m. size of 1.375″, the film manufacturers have actually been cutting to a maximum width of 35 m.m. or 1.3779″ and not 1.375″, and a minimum of 34.95 m. m. This being the case, and as 35 m. m. is 1.3779, and not 1.375, it seems highly desirable to correct our standard.

It also appears that most of the positive film is now being perforated with round corners in the sprocket holes. Negative film is still being made with square corners. This would necessitate standards varying in this respect for positive and negative raw stock.

The 16 m.m. film seems to be coming into general favor, and it would seem desirable to standardize the dimensions for this film also.

Recommendation

Therefore, to bring this whole matter to a head, your Standards Committee instructed Mr. J. G. Jones to prepare a complete report showing all dimensions of 35 m.m., 28 m.m. and 16 m.m. film. This report has been submitted to all film manufacturers, and is presented herewith, with a recommendation that the Society accept the report preparatory to officially standardizing it after the usual six months consideration.

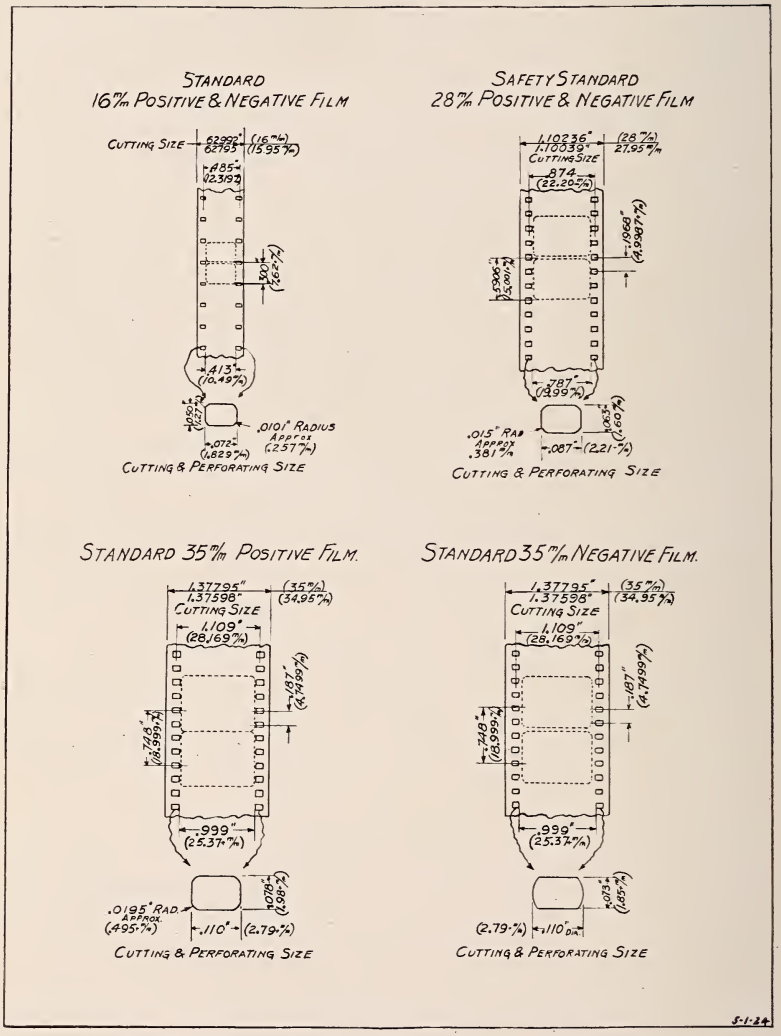

STANDARD
16 m/m POSITIVE & NEGATIVE FILM
CUTTING SIZE
.62992" (16 m/m)
.62795" (15.95 m/m)
.485" (12.319 m/m)
.300" (7.62 m/m)
.413" (10.49 m/m)
.050" (1.27 m/m)
.0101" RADIUS APPROX (.257 m/m)
.072" (1.829 m/m)
CUTTING & PERFORATING SIZE
SAFETY STANDARD
28 m/m POSITIVE & NEGATIVE FILM
1.10236" (28 m/m)
1.10039" 27.95 m/m
CUTTING SIZE
.874 (22.20 m/m)
.1968" (4.9987 m/m)
.5906" (15.001 m/m)
.787" (19.99 m/m)
.063" (1.60 m/m)
.015" RAD APPROX .381 m/m
.087" (2.21 m/m)
CUTTING & PERFORATING SIZE
STANDARD 35 m/m POSITIVE FILM.
1.37795" (35 m/m)
1.37598" (34.95 m/m)
CUTTING SIZE
1.109" (28.169 m/m)
.187" (4.7499 m/m)
.748" (18.999 m/m)
.999" (25.37 m/m)
.078" (1.98 m/m)
.0195" RAD. APPROX. (.495 m/m)
.110" (2.79 m/m)
CUTTING & PERFORATING SIZE
STANDARD 35 m/m NEGATIVE FILM.
1.37795" (35 m/m)
1.37598" (34.95 m/m)
CUTTING SIZE
1.109" (28.169 m/m)
.187" (4.7499 m/m)
.748" (18.999 m/m)
.999" (25.37 m/m)
.073" (1.85 m/m)
(2.79 m/m) .110" DIA.
CUTTING & PERFORATING SIZE
5-1-24

FIG. A

You will note (Fig. A) that in the case of the 35 m.m. film, we are recommending two standards; one for negative film and one for positive film. This is for the reason that we are recommending the use of rounded corners in the perforations of positive film. The need for perforating positive film with rounded corners has been apparent for a considerable length of time. The steadily increasing speed at which the films are run has made this demand even more urgent. Exhaustive tests have been made which show conclusively that the running life of the film is materially increased by the use of round corners in the perforations.

There is no difficulty experienced in printing on positive film perforated in this manner from negative film with flat side, round end style, or Bell & Howell standard perforations.

The increase in width of the perforation in 35 m.m. film from .073″ to .078″, has been found necessary to accomodate the varying sizes and designs of sprockets, thus considerably reducing interference, especially with shrunken films.

In connection with the cutting width, you will note that the tolerance for the minimum dimension for all sizes is .05 m.m. below the basic sizes, so that the cutting width will be nothing over and nothing under these limits.

Aperture Plate Dimensions

It is recommended by the Standards Committee that the Society call attention to the importance of retaining the existing ratio of three to four between the height and width of the picture when introducing any new size of motion picture film; in order to permit direct reduction or enlargement from existing sizes.

Your committee believes it desirable to establish standard dimensions both for camera and printer aperture masks. We have already standardized the dimensions of the projector aperture. (No. 14 Transactions May, 1922.)

It is felt that the question as to whether or not it is desirable to project a black border with the picture, is one which should be settled by vote of the Society after seeing a demonstration, which we shall proceed to give.

As the aperture size for projectors for 35 m.m. film has been approved by the Society at the Boston Meeting May, 1922, your Committee thought it desirable as well to establish standard dimensions for the camera and printer. This question came up at the Atlantic City Meeting, May 1923, at which time discussion brought up the point as to whether in so standardizing, it would be possible to follow the example of the Incorporated Association of Kinematograph Manufacturers, Ltd., as in so doing the picture when projected would have a black border due to the camera aperture being smaller than the projector aperture.

Your present Committee has given this matter further consideration and has prepared a film in order to give a practical dem-

onstration so that their action may be guided by the judgment of the Society in standardizing the size of apertures of cameras and printers.

This picture was taken with a Moy camera with regular and special size aperture plates, mounted on a tripod which did not hold the camera very steady so that it met the conditions very well for this demonstration.

(SHOWING THE FILM)

No doubt you will all agree that the picture showing the black border appears to be more stationary than the one framed by the projector aperture.

Two lantern slides have been prepared which will show the existing conditions as to the various sizes of apertures in cameras, printers and projectors. No names of apparatus are given in this illustration and will be referred to by letters.

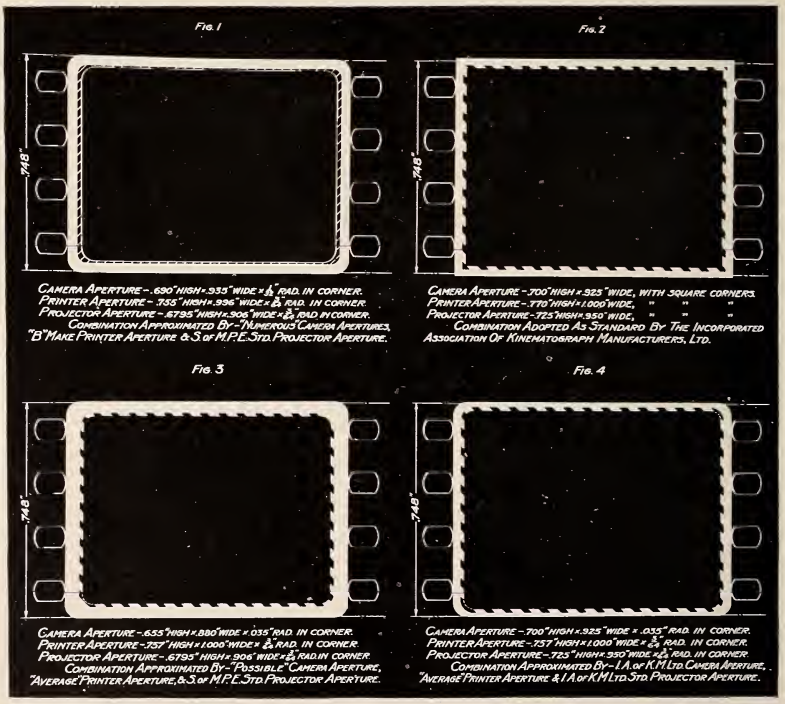


Plate No. 1

Figure 1:

Shows the size of three different apertures super-imposed. The dimension .748″ is equal to four pitches of standard film perforations. The single line cross hatch shows the size of aperture in "B" make of

camera as the negative would appear. The double cross hatch section shows the size of "B" make printer, this includes the black border which shows the amount the printer aperture overlaps the camera aperture. The clear outline shows the size of the "C" make projector aperture, the size of this being .6776″ high by .908″ wide with a corner radius of 1/16″.

You will note that with a condition of this kind, it would not be possible to have the aperture of the projector large enough to allow the black border.

Figure 2:

The black outlines show the "B" make printer aperture size; the cross hatch section shows the "A" camera aperture size; and the clear outline shows the "C" make projector aperture size.

In this case the positive film would have a black border but would be considerably larger than the projector aperture.

Figure 3:

You will note the size of the "C" make camera aperture and "B" make printer aperture are the same length and very little difference in height, the height of the camera aperture being somewhat greater than the printer aperture.

In this case you will see there is no black border on the positive film.

Figure 4:

The black border shows the outline of the "B" make printer aperture. The cross hatch area shows the size of the "A" make camera aperture, and the clear line area shows the "D" make projector aperture.

You will note that all of the projector apertures are approximately the same size.

Plate No. 2

Figure 1:

The black border outline shows the "B" make printer aperture; the cross hatch section shows the outline dimension of a great many makes of cameras; while the clear line area shows the projector aperture size as adopted by the Society. This is practically the prevailing condition at present.

Figure 2:

Shows the size of camera, printer and projector apertures as adopted by The Incorporated Association of Kinematograph Manufacturers, Ltd. The continuous black border shows the size of the printer aperture; the extreme limits of clear area show the size of the projector aperture; while the area included within the black projections shows the camera aperture; thus giving a black border projected which would be about .012″ margin between the camera and projector apertures. The total width of the black border, of course, would be the difference between the camera and printer apertures. You will also note in this case that the camera aperture's size, or size

of picture that would be projected, is somewhat larger than the aperture of the projector compared in the previous cases.

Figure 3:

Shows a combination of aperture sizes that do not exist at the present time, but is shown as an example of what could be done by making the camera apertures smaller. The projector aperture in this case carrying the dimensions adopted by this Society, and the

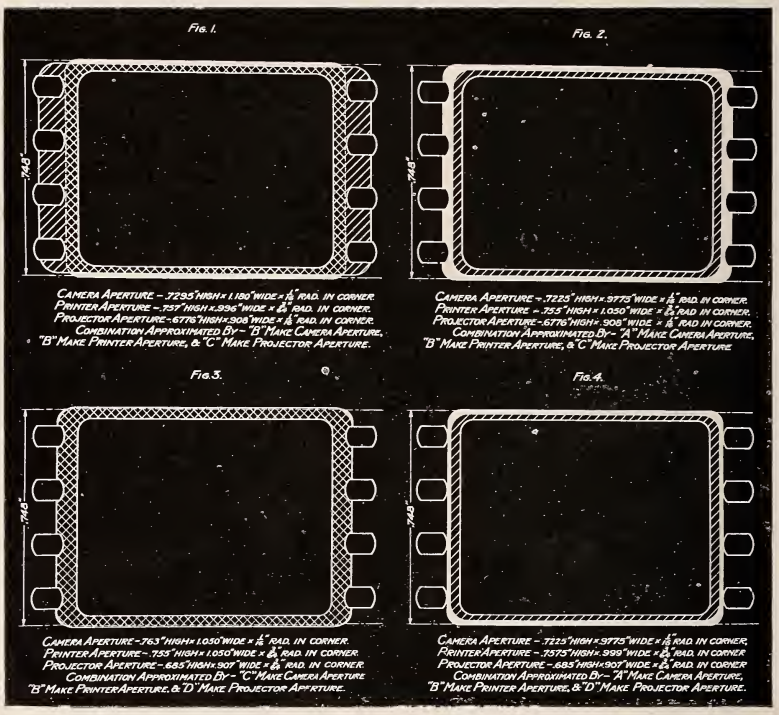


Plate No 2.

printer aperture represents the existing average conditions of all machines which we have been able to measure. In this case the size of the camera aperture as shown would be somewhat smaller than any of the existing projector apertures, so that the outside dimensions of the picture on the screen would be smaller by approximately 3 to 4½ per cent, or a reduction in screen area of about 6 to 7½ per cent.

It would hardly seem proper to make any modification that would reduce the size of the picture on the screen.

Figure 4:

The dimension of the outline black border is the same as in Fig. 3. The dimensions of the extreme clear area would be the size

of projector aperture which is somewhat larger than the dimensions standardized by this Society, being .045″ greater in height and .044″ greater in length. The dimensions of the area included between the projections would be that of the camera aperture and would be the same as shown in Fig. 2 except with rounded corners.

This would mean that the size of all projector apertures and camera apertures would have to be modified. Some of the camera apertures would have to be made larger and some smaller in order to meet this condition. The projector apertures, as aforesaid, would all have to be made somewhat larger—(approximately .025″).

It would seem, therefore, *if* it is not desirable to adopt the principle of the black border, that the dimensions as shown in Fig. 1, Plate 2, would be about the right size of camera and printing machine apertures to be adopted as standard. With this arrangement, any side weave of the film would not show the clear margin around the picture.

Observation Ports

The Committee feels that it would be a desirable thing for the Society to take some action which would tend to prevent further construction of observation ports which are altogether too small for satisfactory service. No port should be used which does not allow the projectionist to see the whole of the screen when standing in his normal position.

The Committee recommends that the size of the observation port be standardized at 16″ square, with its center located 5′ 3″ above the floor, based on a zero projection angle. The center of the port to be lowered one inch for each one degree drop in angle of projection.

Nomenclature

The Committee, after very careful consideration, recommends changes in our present nomenclature as given below. The same numerals are used as in our present nomenclature.

	Present Definition	*Recommended Definition*
1. Action	The director's signal to the players to begin performing	It is recommended that as this is a colloquialism, we eliminate the word and its definition.
2. Arc	A column of very hot light-emitting gas, carrying an electric current sustaining this condition.	Not peculiar to Motion Picture Industry, therefore recommends elimination from nomenclature.
5. Camera	The director's signal to the photographer to begin taking the scene	As this is simply a colloquial signal, and non-essential to our nomen-

	Present Definition	*Recommended Definition*
		clature, it is recommended to remove this term and its definition from the list.
6. Change-Over	In projection, the act of changing from one projector to another without interrupting the continuity of projection	In projection, the act of changing from one projector to another preferably without interrupting the continuity of projection.
10. Cutting	Editing a picture by the elimination of unacceptable film	Editing a picture by eliminating unsuitable subject matter therefrom.
18. Douser	The manually operated door in the projecting machine which intercepts the light before it reaches the film	The fire-proof shutter usually mounted on the lamphouse of a motion picture projector or stereopticon by means of which the light may be intercepted before it reaches the film or slide.
24. Fade-Out	The gradual disappearance of the screen picture into blackness. (The reverse of fade-in)	The gradual but finally complete disappearance of the screen image. (The opposite of fade-in).
41. Lantern Picture	A still picture projected on the screen by a stereopticon	Stereopticon or Lantern picture: A still picture projected on the screen by suitable means.
42. Lantern Slide (Stereo Slide)	A transparent picture for projection by a stereopticon	Stereopticon or Lantern Slide. A single transparent picture designed for projection.
53. Multiple-Reel	A photoplay of more than a thousand feet of film in length	Multiple Reel Picture: (As applies to 35 m.m. film). A photoplay of too great footage to be placed on a single thousand foot reel. In Practice a term applied to photoplays requiring more than three, one thousand foot reels to hold it: photoplays of two and three reel length being termed "two-reelers" and "three-reelers."
57. Opaque Projector	Lantern for optically projecting opaque objects, picture post cards, or the like	As such instruments are practically never used in the motion picture industry, it is recommen-

	Present Definition	*Recommended Definition*
		ded that we eliminate the term and its definition.
73. Retake	A second photograph of a scene	A repetition of the operation of photographing a scene or the resulting negative.
77. Scene	The action taken at a single camera setting	It was felt that the present definition is inadequate, but no better one has been suggested. Suggestions from the membership would be welcome.
80. Shutter	A moving element, usually a disc, which intercepts the light in a motion picture apparatus one or more times for each frame	A moving element, usually rotating, which intercepts the beam of light in a motion picture camera, projector or printer, one or more times during each cycle.
85. Spot	The illuminated area on the aperture plate of motion picture apparatus	The illuminated area on the cooling plate of a motion picture projector.
87. Stereopticon	A lantern for projecting transparent pictures; i.e., lantern slides, often a double lantern for dissolving	Stereopticon or Optical Lantern: An apparatus for optically projecting transparent still pictures. It is recommended that any reference to single or dissolving lanterns be eliminated from the nomenclature.
89. Take-up (Noun)	The mechanism which receives and winds the film after it passes the picture aperture	The mechanism by means of which a film is wound upon a reel after it has passed through the projector, camera, printer etc., mechanism.

Definitions for the following terms were recommended in last year's Committee report, but have not been adopted by the Society. Their recommendations, together with the recommendations of the present Committee, are given as follows:

	Definition under Consideration at Present	*Recommended Definition*
1. Moving Period	That portion of the picture cycle during which the film at the aperture is in motion. This period is expressed in degrees of revolution of the fly wheel when 360 degrees are equal to one cycle	It was decided to accept this definition as given.

	Present Definition	*Recommended Definition*
2. Observation Port	An opening in the front wall of the projection room through which the projectionist observes the screen	It is recommended that this definition be accepted as proposed with the exception that the word "front" in front of "wall" shall be omitted.
3. Picture Cycle	The entire series of mechanical operations which takes place between the positioning of one frame of a motion picture film and the positioning of the next frame	It was recommended to leave this definition as at present.
4. Projection Periods	Those periods during the picture cycle during which the picture is projected upon the screen.	The total fraction of the picture cycle during which the picture is being projected.
5. Projection Room	A room or enclosure from which motion pictures are projected	Projector Room: A room or enclosure from which motion pictures are projected.
6. Stationary Period	That portion of the picture cycle during which the film at the aperture is stationary. This period is expressed in degrees	That portion of the picture cycle during which the film at the aperture is stationary. This period is expressed in degrees of revolution of the fly wheel when 360 degrees are equal to one cycle.

The following new terms and definitions are offered.

Cooling Plate

A shield or baffle composed of one or more plates mounted in front of the film aperture forming an air gap to prevent overheating the aperture plate.

Aperture

The opening in the aperture plate at which each individual picture is situated during exposure, printing or projecting respectively.

Aperture Plate

In a motion picture projector, printer, or camera, a plate of metal containing the actual aperture opening.

Film Gate

A hinged or sliding plate provided with tension springs holding the film against the aperture plate.

Signed
L. C. Porter (Chairman)
J. G. Jones
F. F. Renwick
F. H. Richardson.

SUMMARY

Standards

The Committee submitted complete dimensional drawings for 35 m.m. positive and negative film, the former having rounded corners and the latter square in the perforations, 28 m.m. film and 16 m.m. film, as shown in Fig. A. The dimensions of 35 m.m. positive film were referred back to the committee. The dimensions of 35 m.m. negative film and of the 28 and 16 m.m. film were accepted by the Society.

The committee gave a demonstration of pictures projected with and without a black border and submitted data re: The sizes of various camera and printer aperture plates, Plates I and II. Size of Projector aperture was standardized by the Society in May 1922 (No. 14 Transactions). If it is decided to adopt the principle of the black border, it would be necessary to modify the size of all projector and camera apertures. The committee recommends the dimensions for camera and printer apertures shown in Fig. 1, Plate II. The matter was referred back to the committee for further consideration.

The Committee recommends standardization of an observation port 16″ square with its center 5′ 3″ above the floor for a zero projection angle, the center to be lowered one inch for each one degree drop in angle of projection. This recommendation was accepted by the Society.

The Committee recommended retaining the existing ratio of three to four between height and width of pictures when introducing any new size of film. The Society accepted this recommendation.

The Society instructed the committee to investigate the question of projection speeds and report at the next convention.

Nomenclature

The committee recommended changes in the definitions of the following terms, the numbers used being the same as in the present published nomenclature list:

Term	*Action of Society*
(1) Action	Voted to eliminate from Nomenclature
(2) Arc	Refered back to Committee
(5) Camera	Voted to eliminate from Nomenclature
(6) Change-Over	Recommended definition accepted
(10) Cutting	" " "
(18) Douser	" " "
(24) Fade-Out	" " "
(41) Lantern Picture	" " "
(42) Lantern Slide—Stereo Slide	" " "
(53) Multiple-Reel	" " "
(57) Opaque Projector	Voted to eliminate from Nomenclature
(73) Retake	Referred back to Committee
(77) Scene	" " " "
(80) Shutter	Recommended definition accepted
(85) Spot	" " "

(87)	Stereopticon	Recommended definition accepted
(89)	Take-up (noun)	" " "
(a)	*Moving Period	Accepted as stands
(b)	Observation Port	Recommended definition accepted
(c)	*Picture Cycle	Accepted as stands
(d)	Projection Periods	Recommended definition accepted
(e)	*Projection Room	Accepted as stands
(f)	Stationary Period	Recommended definition accepted.
	Definitions for the following were presented for the first time:	
(g)	Cooling Plate	Referred back to the Committee
(h)	Aperture	Recommended definition accepted
(i)	Aperture Plate	" " "
(j)	Film Gate	Referred back to Committee.

* Each of these definitions has stood before the Society without change for the requisite six months period and therefore become official Nomenclature.

The committee feels that the discussion of the Standards and Nomenclature Committee is of such importance that it warrants publication and it is accordingly given herewith.

DISCUSSION OF STANDARDS

MR. PORTER: I think it will be best to take up the Standards part first and then the Nomenclature.

We have previously prepared and sent to the entire membership a preliminary report of how things stand, so I don't think it is necessary to take time to read the history again but rather to go directly into the work of discussing the Standards proposed.

MR. PORTER: Is there any discussion on the proposed dimensions for 35 m.m. positive film?

DR. GAGE: I merely wanted to inquire whether the dimension for 35 m.m. 1.3779″ was the maximum for tolerance limits.

MR. PORTER: I am going to ask Mr. Jones to answer the questions on this point.

MR. JOHN JONES: That shown is the intended tolerance for 35 m.m. size. You must have some tolerance on freshly cut film.

MR. CRABTREE: I suggest that if these cuts are reproduced they be enlarged to page size; at present it is difficult to read the lettering on them.

MR. RICHARDSON: One of the principal points discussed by the Committee, the one that brought up the discussion, was the radius of the corner (indicating).

MR. JOHN JONES: That may vary, but it must not interfere where the sprocket engages. This radius (indicating) must not interfere. You see the specifications, 19/1000ths approximately, indicate it can be a trifle more or less. We found this radius would be about right.

MR. HUBBARD: I should like to ask Mr. Jones if it has been established that this style of perforation has better lasting qualities than the other; what tests on the actual use of the film have shown.

MR. JOHN JONES: Exhaustive tests were made.

MR. HUBBARD: I mean on actual use of the film in the theatres. What reports do you get?

MR. J. G. JONES: The reports are very good indeed. The only request for the old style perforations on positive film has been for use in making titles direct on the positive. This was owing to the pilots in the title camera not having been changed to fit the new style perforations. We have received a letter from abroad complimenting the changes to the new style perforations very highly.

MR. CHANIER: I want to call your attention to the fact that the flat part is only .071; in the Bell & Howell it is .08228 and I think there is more chance of interference by the sprocket teeth in this perforation than in the other. I think we should have round corners but the flat part the same as on the Bell & Howell.

MR. JOHN JONES: We could not do that very well.

MR. CHANIER: You can make the perforation longer.

MR. JOHN JONES: Then you reduce the edge margin.

MR. CHANIER: The length of the Continental perforation is .118 and the flat is the same as in the Bell & Howell. The narrower space between perforation and edge of film would have no importance.

MR. JOHN JONES: The idea was to make use of some of this (indicating). The perforation should have a fillet coming down here (indicating).

MR. CHANIER: You are figuring on rounded sprocket teeth.

MR. JOHN JONES: Yes, very slightly. The sprocket teeth should not have sharp corners.

MR. BRIEFER: The proposed type of perforation appears logical because it has no corner, but I think the Society should not definitely commit itself on this type of perforation. Some experiments with which I am familiar, cast a shadow of doubt as to its thorough effectiveness. This may be the best perforation we can get, but I think we should go a little slow and recommend it only provisionally. If it is found after two or three other meetings of the Society that it has proven itself, it would be well then, to make it a recommendation of the Society. There is no doubt that this design looks better than the Bell & Howell standard, but, with the present type of sprocket tooth, it does not appear as having greater strength. I have not had sufficient experience with this proposed type to know whether it is the better perforation but, I am sure we should not commit ourselves on the proposition until it has proved itself worthy.

MR. JOHN JONES: For your information it has been used for about a year, not in full practice but several million feet have been perforated this way and research work for some time before that has been carried on, and considerable time and money has been spent to prove that it was superior to the old perforation. Otherwise, it would not merit the expense of going into it.

MR. BRIEFER: I realize that, but I think we should receive from outside sources more information to prove that it is better. I have no doubt that a great deal has been done, but this thing should

have a general public trial before an organization of this character commits itself to it.

Mr. Chanier: I should like to ask how the tests were made. Were reels of film run through machines or were different styles of perforation run through together? I have made tests with the three styles of perforation and sent them through the regular routine, and the Continental was found slightly superior to the rectangular. In all tests did you have the three kinds of perforations on each reel?

Mr. John Jones: Yes, we have done this but running on would not be conclusive specimen through an exchange. Different style perforations should be tested under the same conditions in order to get accurate comparisons.

Mr. Briefer: I might add that my paper scheduled for Thursday may provoke some discussion on the two types of perforation.

Mr. Richardson: I don't agree that these laboratory experiments are altogether conclusive. They are largely theoretical, but when a film goes out it is subject to certain abuses in practice, and these come from many sources. You may make an experiment in a laboratory with known conditions, and when the film comes into use it will go through a projector with undercut teeth, with hooked teeth, with an abnormal strain tension at the gate. In all my experience I do not remember a sample that has broken between the sprocket holes and the edge of the film unless it first broke between the sprocket holes which is proof that that portion of the film has ample strength. I have had thousands and thousands of samples of film with cracked sprocket hole corners at the upper edge as the film is in the projector, meaning there was too much tension on the take up, and others cracked at the opposite corners, indicating too much tension at the gate, but I have never found a crack at the curve of the sprocket hole where there was no sharp corner. I believe Mr. Griffin, Mr. Dennison, Mr. Bowen, and others will bear me out in this proposition, so that the basic trouble lies in sharp corner sprocket holes. That is the basis of practically all the damage in the way of cracks at sprocket holes. I have found they have broken in the center of round corner sprocket holes, but not at the corner.

Mr. Vinten: I am going to read a paper dealing with this from the English Standards Committee. They take the biggest exception in this matter to the increased width. I believe it was arranged to engage six teeth or more and allow for the shrinkage. We felt that the alterations should be made to the sprocket teeth of the machine because I believe your researches showed there is a large variation in projectors and the standardization should be taken up at this end and not the standard film altered. They also consider that the corner is beneficial but should not take up more of the face than the Bell & Howell. They want to know whether the sprocket has to be rounded to take that radius of the corner where the film shrinks. They think it is a step in the wrong direction to increase

the width against the negative film which leaves you with a negative stock of a different size.

MR. JOHN JONES: Are you speaking for the British Society?

MR. VINTEN: For the British Society.

MR. CHANIER: I want to mention that the cutting width of the film has been changed from 1.375 to 1.3779. The former is the standard all over the world. I have a publication here giving the standard in England, France, Germany and the U. S. as 34.92 m.m. or 1.375″. The American dimensions are taken from the S. M. P. E. standards adopted in 1917.

MR. JOHN JONES: You say all over the whole world; in what proportion? For about seventeen years all the 35 m.m. film the Eastman Kodak Company has sent out has been cut to these dimensions.

MR. CHANIER: In 1914, 1915 and 1916 I checked up the width of the Eastman Kodak Company film as a regular business at the same time as the perforation, and it was 1.375 or below on fresh cut film.

MR. J. G. JONES: Your method of measuring might show a slight variation from that of the workman, also the length of time elapsed after the film was cut undoubtedly would give you somewhat different reading.

MR. CHANIER: That is my experience.

DR. KELLNER: Mr. President, If such a motion is in order I move to refer this matter back to the committee.

MR. PORTER: I might say that when these recommendations were prepared they were sent to the various film manufacturers, and in justification to Mr. Chanier I will say he sent an answer promptly along the lines just presented. None of the manufacturers entered any objections.

PRESIDENT JONES: May I ask do you mean that all the dimensions be referred back or only those referring to 35 m.m.?

MR. PORTER: As I understand it, we are discussing only 35 m.m. positive.

PRESIDENT JONES: That is only a matter of being perfectly definite. You have heard the motion. Is there any further discussion?

MR. VINTEN: I suggest that the English and American societies get together before the matter is settled. I think whatever is done should become universal.

MR. CHANIER: I move that the matter be taken up with the French society if there is one.

MR. VINTEN: There is a German one but no French.

MR. CHANIER: Let us take it up with them, then.

PRESIDENT JONES: I think those suggestions can be given directly to the Standards Committee. The motion, then, as amended will be put. (Motion duly passed).

MR. PORTER: Next, we present to you the proposed dimensions

for 35 m.m. negative film. I think the Chairman's suggestion of asking for any objections is the quickest way of handling this.

MR. BRIEFER: I move that the dimensions for negative film be adopted. (Motion seconded).

PRESIDENT JONES: Is there any discussion?

MR. CHANIER: The same thing comes in as in the positive—the cutting width.

MR. BRIEFER: I think the difference in width is unimportant. The dimensions between perforations is the important thing.

MR. VINTEN: The English Society gives a tolerance on these limits and in connection with the negative there is 35 m.m. width with a plus limit and the positive only a minus limit.

PRESIDENT JONES: I should state at this point that all the action we can take on this today is simply preliminary adoption; it must stand before us for six months before being approved, so that we are merely accepting today the recommendations.

MR. RENWICK: If we are to be consistent should we not refer back the dimensions of negative as well as of positive stock so that they can be discussed together with the British and other similar societies?

MR. PORTER: I might say that your previous Standards Committee had been in touch with the English society, and we have the dimensions standardized by the English, and while your chairman has not been in touch with them, I know your previous chairman was not successful in this, but I don't want Mr. Vinten to get the impression we don't know what they are doing.

MR. MCNABB: I should like to say with reference to the width of the negative, that existing apparatus such as printers or camera would not be affected, but any change affecting the perforation hole or gauge would be a step in the wrong direction. I don't think change in width will make any difference.

PRESIDENT JONES: As I interpret the point, it should.—It is a question of whether we deem it advisable to get in agreement with the English society on width. There is no discussion on the negative stock except the width. Do you wish to adopt this recommendation as it stands or to include with the positive the negative for uniformity of agreement with the foreign societies? Are you ready for the question? The motion is that the recommendations as stated on the chart be accepted.

(Motion duly passed.)

MR. PORTER: Next, we will present for your consideration the proposed dimensions of 28 m.m. film.

PRESIDENT JONES: Is there any discussion on the dimensions for the 28 m.m. film? If not, what is your wish? (Motion made and seconded that the dimensions be accepted.)

MR. RENWICK: Before that is voted upon may I say that it seems to me anomalous to refer back to the Committee the proposed

new perforation for 35 m.m. stock and approve a similar perforation on 28 m.m. stock.

MR. JOHN JONES: The 28 m.m. has a similar perforation to the 35 m.m.

MR. COOK: The French perforation always had the fillet in the corner. Eastman has only recently adopted it. Bell & Howell had nothing to do with 28 m.m. Pathé always had a small fillet in the corner, and Eastman has recently adopted something similar. There is no reason why there should be further discussion on this.

PRESIDENT JONES: Any further discussion? If not, are you ready for the question that we accept the recommendation of the Committee on 28 m.m. positive and negative film?

(Motion duly passed.)

MR. PORTER: The 16 m.m. film seems to be coming into general use and, therefore, your Committee felt it advisable to recommend its standardization.

MR. COOK: It would seem to me that on the 16 m.m. film, as this has been originated by the Eastman Kodak Company, and, as far as I am aware, it has not been manufactured by any other company, t would be wise for us, at this early stage to adopt something definite such as the existing form of perforation and avoid any discussions of the type we have been having for the last few minutes. Unless there is some one having a decided objection to this, I make a motion that it be adopted as specified by the Eastman Kodak Company.

(Motion duly passed.)

MR. PORTER: It is the recommendation of the Standards Committee that the Society call attention to the importance of retaining the existing ratio of 3 to 4 between the height and width of the picture when introducing any new size of motion picture film in order to permit enlargement or reduction from existing sizes.

MR. BRIEFER: I move that we adopt the recommendation of the Committee. (Motion seconded.) (Passed.)

MR. PORTER: Your committee believes it desirable to establish standard dimensions both for aperture and printer masks. Mr. Jones has prepared a discussion of this question with a demonstration, and I will ask him to present it at this time.

(Mr. Jones' paper read.)

MR. GRIFFIN: Seeing these apertures projected reminds me that as machine manufacturers we are getting demands for square cornered aperture plates. I don't know what the reason is, but the theatre managements seem to think square corners are better than round ones, and I think we have shipped out a thousand in the several months on request.

MR. VINTEN: Could we have the reason why the round corner was adopted in the first place? I think it was because the early lenses were poor in the first place and did not cover well, but we usually visualize oil paintings, and so forth with a square corner.

Mr. Townsend: Do I understand that the idea of making a wide black border inside the projector area is under serious considerat on?

President Jones: Yes, that is the point under consideration.

Mr. Townsend: I should like to point out one serious objection to this. There are more theatres having a distorted picture owing to angle of projection than otherwise. The aperture plate is either filed to overcome the distortion or the screen masked in with black to make the sides perpendicular. If we make a black border on the film inside the projector aperture the theatres cannot overcome the Keystone effect without coming away inside the film again, and they wouldn't use the black border in this event.

Mr. Vinten: The point just made came before our committee and settled our decision.

Mr. Richardson: If you can find anything, which will cause the architect to use common sense in this respect I am for it. If the man will keep within reasonable bounds in projection angle the distortion will not be such that it must be removed. In some theatres the picture is as high as it is wide, and is, of course, highly distorted. Such a picture is not as pleasing to the eye as an undistorted picture. Whether it is advisable that this Society take this kind of action, I cannot say but I would not give the architect's practice a moment's consideration. They are defying the action of this society. The architect seems totally lacking in knowledge as to the requirements of projection and entirely unwilling to seek advice or information, therefore why should we consider him until such time as he shows disposition to change his attitude.

Mr. Griffin: I think that black border would help Mr. Richardson's and my point very much. We have been fighting to get the projection room down where it belongs so that the picture will be projected from the right point. I don't know how other companies are bothered, but we have many inquiries about projection, and they expect us to make an aperture plate to fit those conditions. With the border on the film they could only blame themselves, and I am for it.

Mr. Vinten: Another advantage of using the small camera aperture is that the camera man does get on the sheet the actual picture he photographs; nothing is cut off.

Mr. John Jones: The first question is shall we adopt the sizes of camera and printer apertures allowing a black border without making the picture smaller?

Mr. McNabb: It is intended to print all that is on the negative, and standardization is unnecessary. Why bring in the printer?

Mr. Porter: Because at the last meeting the Society instructed the Committee to do so.

Mr. McNabb: I think it is foolish.

Dr. Gage: It seems to me that in a way the discussion is very valuable; but I don't know what weight the decision will have. It has pointed out to the producers who have to do with taking the pictures that it is advantageous to have a black border in the print itself which

is not to exceed a certain size; I think this can then be carried out in practice. The producers do mat in and iris down the picture to a small size in order to produce certain pictorial effects, and I think the result of what has been shown here is that a desirable pictorial effect is produced by a mask not exceeding a certain size.

MR. RICHARDSON: I move that the Committee be instructed to draw up a recommendation to standardize the camera aperture or mask so that the black border will show.

(Motion seconded.)

MR. TREISS: If you standardize camera aperture and not the printing aperture, how can you get the black border—if your printer has the same aperture as your negative?

MR. JOHN JONES: You can't; it must be larger.

MR. PALMER: I think in connection with this matter we should have the discussion on the picture with the square corners. In England they use pictures with square corners. I think it has advantages, and I should like to hear a discussion on this.

PRESIDENT JONES: There is an action before the house to be voted upon before we discuss another matter. Is there any further discussion on the action to instruct our committee to standardize the camera aperture so that we shall have a black border showing? I rule that it does not involve corners.

MR. JOHN JONES: Before we put the question I should like to call attention that the aperture for the projector has been standardized with a fillet in the corner. If you standardize on the corner with the black border, shall we discontinue the round corner?

MR. GRIFFIN: As I stated before, there is getting to be a demand for square cornered aperture plates; which are we to standardize?

MR. BRIEFER: If it is only a question of the black border, why discuss the other?

PRESIDENT JONES: That is my ruling. The question is before you in the original form. I will attempt to repeat the motion—that we recommend to the Standards Committee that they recommend a standard size for camera aperture so that we have a black border.

(Motion duly passed.)

MR. JOHN JONES: We have already recommended dimensions for camera and projector aperture.

(Slide again projected.) The printer aperture can vary, but it must be large enough to take in the full picture and enough for side weave.

PRESIDENT JONES: That opens up another discussion of this point. I do not consider that the motion approves the dimensions recommended by this Committee. The motion merely instructs you to submit dimensions.

MR. PORTER: After studying the question very carefully, we have recommended dimensions which we believe are suitable. Some existing apparatus must be changed; we recommend the dimensions which Mr. Jones pointed out in the slides.

President Jones: As I interpret the proceeding, the Standards Committee are submitting a recommendation of dimensions. If you wish this to be reconsidered by the body as well as the question of square corners we need a motion to this effect or a motion to accept the recommendation.

Mr. Richardson: I did not have this before me and I had forgotten that we had recommended these dimensions (laughter). In order to get the matter before the house I move that the dimensions recommended by the Committee be adopted.

Mr. Vinten: Do those figures agree with the English dimensions?

Mr. John Jones: These (indicating) are the British adopted standard .725, We would adopt the same thing but we have rounded the corners; that is, the printing aperture is .757 and the projector .725 × .95

Mr. Palmer: I amend Mr. Richardson's motion that the dimensions as recommended be adopted with the addition of square corners.

President Jones: Is there a second?

Mr. Griffin: Before we go too far with the adoption of these dimensions I call your attention to the fact that it does not leave much room for the tension shoes which are a definite width on all projectors; I should like to hear Mr. Bowen on this.

Mr. Bowen: The width of aperture will be a serious problem because you run into the sprocket holes and there is little leeway, and it would be ugly to see a sprocket hole projected on the screen. You have the tension shoe question to take care of.

President Jones: Has the Committee anything to say?

Mr. John Jones: This line on the chart is the same as the aperture, and you increase this five one hundred-thousandths.

Mr. Griffin: It will mean that projector manufacturers will have to redesign their gates because our gate is just designed to have only a certain size opening for the light to pass through.

Mr. John Jones: These are .902, .9055, and .908.

Mr. Griffin: If you change these, they will all have to be made larger in proportion.

Mr. John Jones: This can be done, but if you keep them standard it would be well.

Mr. Griffin: We must keep sight of the fact that there are forty odd projectors of ours and plenty of others on the market.

Mr. Richardson: I didn't understand when this was discussed that it was to involve narrowing the tension shoes, because, if that be done, you must increase the tension, and this sets up a very serious objection where a new film is concerned. As against this, new film is largely waxed or treated to some hardening process.

President Jones: I think it is the sense of the meeting that the black border is a good thing but there is some disagreement as to the final recommendation. I suggest that the matter be referred back to the committee.

MR. RICHARDSON: I withdraw my motion. (Second thereupon withdrawn). I move that it be referred back to the Committee.

(Motion seconded.)

MR. VINTEN: Another point in favor of this black border system is that you get two same size pictures on the sheet from two different machines. The film gives you the actual size on the sheet and not the projecting lens.

MR. MCNABB: As long as the matter is being referred back to the Committee, one more point I think might be considered—if we can have the slide, I will show you. (slide projected.) The aperture could be extended to about here (indicating), with the purpose of having the margin of the frame come out into the white line of the perforation. This would facilitate assembly of positives, particularly in fade-outs and fade-ins, where the dividing line is difficult to see.

MR. JOHN JONES: How would this interfere with the producers marking film by the perforations?

MR. MCNABB: This should not interfere, regardless of whether it be done on one or both sides of the negative.

PRESIDENT JONES: It has been moved and seconded that the matter of aperture be referred back for further consideration.

(Motion duly passed.)

MR. PORTER: The Standards Committee feels it would be a desirable thing for the Society to take some action in connection with the observation port being too small. It recommends that it be adopted as 16″ square located above the floor, the center of the port to be lowered one inch for each degree drop in angle of projection.

MR. GRIFFIN: That is a fine recommendation, but I wonder if the Committee took into consideration the fact that the laws in different parts of the country forbid anything like this.

MR. PORTER: We have considered it, and while we do not have available the details of all the laws, it is a situation which I don't think we can control. We think we are making a recommendation here for the benefit of the majority.

(Motion thereupon made and seconded that the recommendation be accepted.)

MR. PALMER: I suggest that the measurement from the floor be changed to the surface on which the operator is standing because sometimes the machine is set on a box.

MR. GRIFFIN: I disagree with Mr. Palmer on this because we are looking ahead and not correcting the existing evils; this is for new construction.

(Motion duly passed.)

MR. PORTER: That completes the part of our report pertaining to standards. If the Society wishes we will pass on to nomenclature.

MR. MCNABB: Can new business be originated at this time?

President Jones: It may be since the chairman has no objection.

Mr. McNabb: I suggest that consideration be given to the standardization of the film splice width for exchanges and theaters.

Mr. Porter: I think this is a good suggestion, and we shall be glad to consider it.

Mr. McNabb: I shall be glad to furnish data on this.

Mr. Porter: We shall be glad to have it and give it consideration.

Mr. Richardson: Either it has been discarded or there is in our practice at the present time something which is very wrong. I have brought it to the Society's attention at every meeting for three or four years. Our Standard projection speed is 60 feet of film a minute. You can't project film at that speed today. The screen brilliancy has become so great that the contrast between light and dark periods is so terrific that if you drop down to 60 you get flicker. Mr. Denison has called attention to the fact that camera speed remains 60. I don't know why, but it really seems necessary to project faster than the camera speed else the action drags. I, therefore, hold that this body should adopt a different projection speed. I believe that the projection speed today should be 70, for reasons set forth.

Mr. Griffin: Might I suggest that this be referred to the Standards Committee? I put this as a motion. (Motion seconded.)

Dr. Gage: I make the amendment requesting that the Committee on projection or optics make some experiments along that line and that they submit results in the form of a demonstration at the next convention.

President Jones: We have no committee on projection or optics.

Mr. Griffin: I move that such a committee be appointed.

President Jones: That is out of order.

Mr. Richardson: I call attention of Dr. Gage to the fact that we make demonstrations of this kind in the theatres every day. Mr. Denison's opinion concerning this matter should be worth hearing.

Mr. Denison: It is true that 60 feet is much too slow. For the sake of a standard it should be changed. The minimum projection speed in theatres is 75 feet a minute. I made some exhaustive tests a few years ago and found a speed of 70 feet a minute took care of every kind of action. At more than 76, the speed of the action is excessive.

Mr. Porter: This question of projection speed has been before the Society on a number of occasions and has been discussed. It seems to me we can't make it a definite standard. I think projection speed should come up under "Recommended Practice," and the Standards Committee should be glad to give this careful study.

President Jones: There is a motion before the house that the projector speed be referred to the Standards Committee.

(Motion duly passed.)

Discussion of Nomenclature

The Committee's recommendations concerning the terms, "action," "camera," and "change over" were agreed to without discussion.

Discussion on the rest of the Nomenclature Report was as follows:

(Recommendation of Committee that definition of "arc" be eliminated.)

Dr. Kellner: I recommend that this be laid over; that is, that it be referred back to the Committee.

(Motion duly seconded and passed.)

Cutting (Present and recommended new definitions read.)

Mr. Palmer: I believe that definition is not complete. Cutting a picture means more than the elimination of unacceptable film; it means putting a picture together in such a way as to add to its dramatic value, and that is one of the very important features in cutting a picture as we understand it.

Mr. Renwick: I think the definition covers this. The thing would not be suitable unless it met this idea.

(Definition thereupon accepted.)

Opaque Projector. (Recommended to eliminate this.)

Mr. Nelson: There is a paper film motion picture on the market, that reflects the picture on to the screen.

Mr. Griffin: I know the machine that the gentleman speaks of, but it is not in use generally, and I don't think it is applicable in this field. (Motion that the recommendation be accepted; seconded.)

Dr. Gage: I think we ought to keep the term, so I am going to vote against the recommendation.

President Jones: The motion has been made and seconded. Is there any discussion on this? (Motion passed.)

Mr. Porter: *Retake* (Present and recommended new definitions read.)

Mr. Chanier: The fact that the photograph is taken twice does not necessarily mean that the second is a retake.

Mr. Briefer: I don't think it matters to us why it was retaken.

Mr. Davidson: I don't think we want any definitions in our minutes that are incorrect. In taking a scene over it means we have only two retakes and one print, and I think Mr. Chanier is correct.

Mr. Renwick. In those cases where three, four, and five retakes are made, is it not true that the middle one is often selected? (Motion made to accept the recommendation.)

Mr. Palmer: It is true that they do take a scene four or five times and select one to go into the final picture, but they don't call them retakes. A retake is a scene taken over because something happened to the camera or the action, making it necessary to take it over.

President Jones: Any further discussion? There is a motion before the house to accept this; it seems there are arguments against it.

(Motion passed to refer the definition back to the Committee.)

Mr. Porter: *Scene* (Definition read.)

Mr. Richardson: I think the studio men should be able to give a definition for "scene."

Mr. Manheimer: I think that could be better defined by the Camera Men's Society or the Studio Directors' Association; unfortunately we have not enough of these men in the eastern branch of the Motion Picture Engineers.

Mr. Brown: I am familiar with both organizations, and important as they are they do not formulate definitions. It is up to the Engineers Society to formulate and define, and we must accept this responsibility.

Mr. Richardson: While that is true, I think it is the province of the Committee to take up the matter with these men to formulate such a definition. I move that it be referred back. (Motion seconded.)

Mr. Griffin: There is a publication on the Pacific Coast called "The American Cinematographer," there must be some one among that membership, who could give you a definition.

(Motion thereupon duly passed that the matter be referred back to the Committee.)

Mr. Porter: *Shutter.* (Present and recommended new definitions read.)

President Jones: Any comments on this definition? (Motion made and seconded that it be accepted.)

Mr. Roebuck: Would it be wise to specify "automatic"?

Voices: No; only in that it is part of a mechanism.

President Jones: Further discussion? (Motion passed.)

Mr. Porter: *Spot.* (Present and recommended new definitions read.)

President Jones: Any comments on this definition?

Mr. Manheimer: In studios they speak of spot lights as spots; I don't know whether this will cause confusion; the term is sort of idiomatic.

Mr. Griffin: I don't think that would interfere with us because the "spot" as we know it is purely as designated here. I move that it be accepted. (Motion seconded.) (Motion duly accepted.) *Stereopticon.* (Present and recommended new definitions read.)

Dr. Gage: I think if we say "stereopticon or" the word after "or" should be "magic lantern." I think we should define a single term or put in the word "magic lantern."

Mr. Porter: Stereopticon is the common term used here in America and optical lantern is that used on the other side, so that we thought they should both be put in.

(Motion passed to accept the definition as recommended by the Committee.)

Mr. Porter: *Take-up.* (Definition read.)

President Jones: Any comments on this definition?

(Motion passed to accept the term as recommended.)

Mr. Porter: Definitions for the following terms were recom-

mended last year but have not been adopted. *Moving Period.* Recommended definition approved without discussion. *Observation port.*) Definition read.)

PRESIDENT JONES: Any comments?

DR. GAGE: In that definition the word "projection room" is mentioned. The vote of the Society a year ago was to call it "projector room."

MR. PORTER: In answer to that I should say that inasmuch as no action was taken at the Ottawa convention the Society has not decided between projector room or projection room.

MR. PALMER: Can't we discuss the definition for "projector room" before we adopt this definition? .

MR. PORTER: I think Mr. Palmer's suggestion is a good one, and if you are willing, we will pass over this definition for "observation port" and take up "projector room." (Definition read.) I might say in connection with this that it is the only one on which our committee was not finally in unanimous agreement.

MR. RICHARDSON: I move that the term "projection room" be adopted. I published just once the proposal of this society to adopt "projector room." I have here endorsements from seventeen local unions and about two thousand letters, every one of which condemns "projector room" in more or less emphatic terms, and only one has favored "projection room." I have letters here from the Philippine Islands, New Zealand, and so on. These men are all opposed to projector room.

DR. GAGE: A year ago at Atlantic City the question came up that the term "screening room" was used, and I think the Society should consider putting in a definition of "screening room." It is a room usually in connection with the studio or exchange in which motion pictures are projected for the purpose of editing them.

MR. DAVIDSON: I think perhaps there is a great deal of truth in what Mr. Richardson said about the time spent in putting across projection room, but 95% of the people still call it a booth. If we go ahead with the name "projection room" for the booth, you will force the architect to call the "projection room" a "booth." You cannot call both "projection rooms," and we will undo what Mr. Richardson is trying to accomplish.

MR. GRIFFIN: I cannot agree with Mr. Davidson because we have the opportunity of seeing many blue prints during the year covering theater plans, and I am glad to see they use "screening room" for that part of the theater, and they use "projection room" quite commonly. I agree with Mr. Richardson.

MR. BRIEFER: Regardless of what we think about it, I don't believe we could get the general public to use the term "projector room" because it is not euphonious. "Projection room" has been

adopted and has the guarantee of usage, so why should we trouble ourselves to change it?

MR. RICHARDSON: I should like to say a word. As evidence that the nomenclature of this society is followed, before we adopted projectionist there was no government using the term; there are now several states in the Union and several Canadian Provinces which have officially adopted the term projectionist, one province having officially declared the term "operator" obsolete.

MR. PALMER: We should like to decide in this meeting to change the name of "projection room" to something else, but I don't think it is within our province to do so. It has always meant a room where people go to see pictures; it is used everywhere.

MR. MANHEIMER: I don't think it makes much difference whether we receive five letters or two thousand letters. In the first place they are projectionists, not engineers or architects. I am in touch with many of the architects of studios, and I know all of them have adopted "projection room" for the room in which pictures are shown in the studio or the exchange. They will continue this, and it will only cause a lot of confusion if we adopt something else.

MR. TOWNSEND: I am not talking for or against either one, but to my mind if you call what I call a "projection room" a "projector room," it covers a room where only projectors are used and several other things are projected from a projection room besides motion pictures through a stereopticon; we have flood lights, spot lights, and so forth.

VOICES: They are all defined as projectors.

MR. RICHARDSON: The exchanges used "projection rooms" years before this society was ever thought of. It is a screening room, not a projection room, because you don't project pictures from it.

MR. MANHEIMER: The projectors are in the same room with the screens in many projection rooms.

MR. PORTER: All I can say is that this question has been up for a year and exactly the same arguments have been presented here as have been presented at previous meetings. I hope you will not refer it back to the Committee; I don't know what more we could do.

PRESIDENT JONES: The motion before the house is that the term "projection room" be adopted.

(Motion duly passed.)

MR. PORTER: That brings us back to the consideration of *observation port*. I should like to ask the other members of the Committee if they are willing to change our recommendation to "projection room." (Committee agreed.) We recommend, then, opening in the front wall of the projection room through which the projectionist observes the screen.

(Recommendation accepted.)

The recommended definition of "picture cycle" was approved without discussion.

MR. PORTER: We are now down to number 4, *projection periods*. (Definition read.)

Mr. Cook: Are you talking about the stationary period of the film or of the image on the screen?

Mr. Porter: About the projection period.

Mr. Cook: Then, that is the same in 4 as it is in 6; the stationary period of the picture is the same as the projection period on the screen.

Mr. Griffin: That is not exactly correct because the projection period is a shorter length of time than the stationary period—much shorter.

Mr. Cook: Are you speaking of the screen image?

Mr. Griffin: Of the screen image; that is, the projection period.

President Jones: I should like to have Mr. Porter read the definition of "picture cycle" already adopted. (Definition read.) It seems to me, then, that that defines a series of mechanical operations and does not refer to the projection on the screen.

Mr. Richardson: That has no application to the projection period.

Mr. Griffin: Everything is correct, I should say, as it stands.

President Jones: Is there further discussion?

Mr. Richardson: I might make that more clear. When we speak of the picture cycle, we define the total mechanical cycle. When we speak of the projection period, we mean the time the picture is actually on the screen.

(Motion made and seconded that the definition be accepted as recommended.)

Dr. Gage: As taken up in Atlantic City, the definition is those periods during which the picture is projected on the screen. To those of us trying to define it, I think it is pretty clear. Whether it is more so as the total fractions of the picture cycle during which a certain thing occurs, I don't know. If we adopt that change it means another six months; if we are prepared to confirm the Atlantic City report, we could vote "no" on this proposition.

Mr. Renwick: I should like to point out with regard to the definition as it stood that there are one or two objections to it. It does not tell anybody in what terms we are to express this projection period. Secondly there is an unfortunate repetition of the word "during." The picture cycle is expressed in degrees, there is no provision as to how this period should be stated, and the proposal is that it should be expressed as the total time of projection expressed as a fraction of the picture cycle.

Mr. Griffin: I don't think you could do more than express it in fractions of the total time. Inasmuch as various projectors today have a different time of stationary period and projection period it is impossible for the Society to set the exact number of seconds.

Mr. Richardson: In addition, the width of the blades and kinds of shutters vary.

President Jones: Are you ready for the question?

(Motion passed to accept the definition as recommended.)

Mr. Porter: *Stationary period.* (Definition read.)

President Jones: Any discussion of this definition?

(Definition accepted as read.)

Mr. Porter: Your committee proposes for the first time the following new definitions:

(Definition of cooling plate read.)

Mr. Richardson: I think it should be "mechanism" instead of "aperture plate," overheating would tend to warp the whole mechanism frame.

Mr. John G. Jones: I don't think there is any mechanism which will not heat if the aperture plate is overheated.

Mr. Richardson: That is necessarily true.

Mr. Roebuck: I think that one of the most important elements to consider is the tension shoes and particularly the springs for the tension shoes. If they become overheated they tend to lose their temper and their tension.

Mr. Griffin: I agree with Mr. Roebuck. I think we could change this to read "tension devices" because that is all you are trying to keep cool; you are trying to protect the tension springs.

Mr. Richardson: Is it not true that in the past mechanisms warped because the projectionist removed the cooling plate? The heating of the mechanism frame sets up heavy stress. Perhaps the frame mechanism has been changed so this would not so much matter.

Mr. Griffin: That was true a few years ago, but we have adopted rugged construction, and I think the thing is well taken care of at this time.

Mr. John G. Jones: Under the heading of "aperture plate" we have included all this mechanism.

President Jones: I think we should take up the aperture and aperture plate definitions first.

(*Aperture.*) (Definition read.)

(Definition accepted.)

Mr. Porter: *Aperture plate* (Definition read.)

(Motion made and seconded to accept definition.)

Mr. McNabb: There are other plates besides those mentioned; for instance, camera men use what is called "auxiliary" aperture plates for viewing.

Mr. Richardson: That would be an "auxiliary."

President Jones: Any further discussion? Are you ready for the question?

(Definition duly accepted.)

Mr. Porter: We are recommending for the first time the definition of "film gate."

(Definition read.)

(Motion made and seconded to accept definition.)

Mr. Roebuck: I think it is misleading not to include the shoes because they are a vital part of the mechanism.

MR. GRIFFIN: I don't think there is a projector made today without shoes to hold the film against the aperture plate.

MR. RENWICK: While I have no opinion on this, I think if we could do it without introducing the shoes we are able to get a definition at this time, for film gate, whereas the matter of shoes involves another definition.

MR. GRIFFIN: It is unfortunate that it would have to wait over, but I think we should have shoes in there because they are an important part of the film gate; it is the shoes I should say that hold the film.

MR. PALMER: It is not necessary for a film gate to have shoes on it because on the new amateur there are tension springs but no shoes.

MR. PORTER: I want to point out to Mr. Griffin that this definition must wait over six months in any case.

MR. DAVIDSON: Is it necessary to have "hinged or sliding"? I saw one the other day without either. There are half a dozen film gates besides that defined.

PRESIDENT JONES: A motion has been made to refer it back to the Committee.

(Motion seconded.)

DR. KELLNER: I wish members would offer us some suggestions in writing so that we shall not be in the same boat at the next meeting.

MR. GRIFFIN: We don't know all there is to know about this, but we shall be glad to help.

(Definition thereupon referred back to the Committee.)

MR. PORTER: That bring us back to the definition of *cooling plate.*

(Definition read.)

PRESIDENT JONES: Any discussion?

MR. BOWEN: I think Mr. Richardson's change in the wording of the definition should stand as he wished to make it because it is not only the aperture but all the other parts of the mechanism you want to keep cool because you are not only trying to protect the film but the shoes, the aperture plate and also the tension springs.

(Definition thereupon referred back to the Committee.)

MR. PORTER: In closing I should like to say that I wish the body would offer suggestions on these things at the present convention. I don't believe there is any necessity for rush or hurry in adopting standards or nomenclature. I think it is better to go slowly and be sure we are right before adopting anything.

(Applause.)

PRESIDENT JONES: I think this committee is to be congratulated on the work they have done, and the Society is to be congratulated on having such a committee.

MR. DAVIDSON: I think the Society has never adopted the definition for the size of lenses. At the present time the president of

our Company asked for this to be referred to the Committee for consideration. Lenses are made of slightly different sizes, and it leads to a great deal of confusion. I am perhaps speaking for more than one manufacturer, and I suggest that the Committee take this under consideration between now and the next meeting.

DR. KELLNER: We have such standards established three or four years ago.

MR. ROEBUCK: In connection with Mr. Porter's advice that the suggestion be made in connection with these definitions, may I suggest that those points which are still for discussion be written out and circulated for our convenience before the meeting is over? I should like to bring up one point in regard to the Deltor shutter. It seems to me that if we would add after "inspecting light" "at will" or "manually operated," I think the safety shutter would be distinguished from it.

PRESIDENT JONES: Mr. Porter will make note of that suggestion.

MR. RICHARDSON: The matter of lens aperture brings up the changing of construction of some projectors. Some projectors cannot accommodate the lens they should use under some conditions, with the result that the lens manufacturers are confined to a smaller diameter factor than should be used.

MR. GRIFFIN: I think Mr. Davidson made a very good point when he suggested that the lens standards be adopted, and I think I understood him correctly to mean the diameter of the lenses and that Dr. Kellner said standards were adopted three or four years ago, but I know that Bausch & Lomb are the only lens manufacturers who are putting out lenses which are not standard. I refer to the Semaphore lens, the No. 1 of which is larger than those we know as No. 1 and the Series II is smaller in diameter than those of any other make. I think some one should get other manufacturers to come to them or Bausch & Lomb should adopt the sizes used by other manufacturers. We have to furnish adapters for all projectors on the market.

MR. PORTER: I think this is an important question and I can assure you that your committee will give it careful study between now and the next meeting.

PRESIDENT JONES: I should like to inquire whether the Society desires to continue the discussion at this time. I think it would be advisable to proceed with the order of the day and I shall so rule.

REPORT OF PUBLICATIONS COMMITTEE

YOUR present Publications Committee has not, for the last two years rendered a report, officially, to the Society on their activities. We feel that the mailing of the TRANSACTIONS to each individual member should be a personal report for the Publications Committee. This report, however, is intended to cover the approximate period of about two years, for which period this committee has been in operation.

If we did not function you would not have received your TRANSACTIONS, and to what extent we did our job satisfactorily may be determined by each member upon reviewing his copy of the TRANSACTIONS.

We have made several errors in the publication of the TRANSACTIONS, for which errata sheets have been issued—but a small percentage of the total were our errors. The combined number of errata sheets printed were but few. Have you, and do you check your TRANSACTIONS when you receive your copy; do you call attention to those publishing the TRANSACTIONS to any errors or omissions? It is advisable to make such corrections as may be deemed necessary as nearly as possible to the publication date. Your Publications Committee will consider it a favor, not a criticism, to know of these errors.

In publishing our TRANSACTIONS, our greatest difficulty is to obtain the prompt return of galley-proofs from the authors. Authors should remember that the Society is holding the Publications Committee responsible for the early publishing of your proceedings, and unless they are received promptly, delay in publication will result. In laying out the publications of our TRANSACTIONS of the Society's meetings approximate time schedules are adhered to as nearly as possible.

It is also impossible to publish the TRANSACTIONS from an economical standpoint unless the copy is given to the printer as nearly complete as possible. Cuts and the setting of type is always more reasonable when contracted for in large quantities. Therefore, practically all the manuscript must be received before the setting of the type. The cost of the TRANSACTIONS would increase to more than double the present price if your committee would insist that each individual paper, as it might be received, be set up and type held for the remainder of the copy.

Therefore, the problem of the Publications Committee is to decrease the cost of our TRANSACTIONS, eliminate as much waste time as possible, obtain speed in printing, and avoid misunderstandings, and errors in so doing. Papers, discussions, reports, etc. are known

only to the Society at their meetings by subjects or authors, after which and until such time as the TRANSACTIONS are mailed to the members, all papers and discussions lose their identification as to author and subject and are only identified by number. This system operates very efficiently and extends to the Papers Committee, Publication Committee, Printer, Engraver, and finally to those mailing the TRANSACTIONS. Instructions as to the mailing of the TRANSACTIONS to members are finally issued to use Item 4 (Membership list) as a mailing list. If you have not notified the Secretary of your new address, you may not receive your copy of the TRANSACTIONS.

The Publications Committee has standardized on a printing specification, and you who may operate this branch of the Society in the future, will find that standard specifications will do much to assist you in obtaining the proper printing estimate, and for those of the future Publications Committees specifications are herewith given:

The Edition (as may be designated by the Board of Governors), pages 220—size print 6″×8¾″, type size 4 1/16″×7¼″, type 10, 8 and 6 point monotype No. 8A to suit copy.

Paper 38×50—140 lb. white empress enamel. Cover 20×36—80 lb. buff antique. Press work black, binder machine folded, side wire stitch and trim. The price complete according to these specifications should be $——— with the following provisions.

A. If the material makes more or less than 220 pages, and an addition or reduction as the case may be of $——— per page.

B. Alteration in the type after it has been set will be charged for at the rate of $—— per hour.

C. Cost of half-tone plates and cuts is not included, but will be furnished at $——— per ——————.

The Committee has also studied the cost and plotted several curves, and suggests that each cut of every paper be studied, reducing it in size, if necessary, and at the same time maintain the value of the cut as an important part of the paper. Cuts should be encouraged, but should be added only where necessary, in that the cost of TRANSACTIONS may be increased very materially, per page, by the number of cuts required in the complete edition.

Cuts and half-tones make our TRANSACTIONS more valuable to those seeking our engineering data, and wherever they are necessary they should be added.

More attention should be paid to the advertising section. Additional advertising should be obtained, and to such an extent only that, we may pay the cost of our TRANSACTIONS.

One feature that should be considered is, do we desire speed of printing or quality. It is almost impossible to obtain both. I have therefore selected quality, using every available effort to obtain speed. Your committee selected the George Banta Press, 450 Ahnaip St., Menasha, Wis., because they are reliable, come well recommended, and deliver quality printing. The Geographical locations of New

York and Wisconsin, make extreme high speed impossible. Had it not, however, been for the delay in receiving the return of the galley-proof and other required information from the authors, there should be no reason, why the TRANSACTIONS could not be in the hands of the members two months after the meeting. I would, therefore, again suggest that the authors be punctual in returning their manuscript to the committees.

For those who may be interested in information on the TRANSACTIONS previously printed I am quoting as follows:

Trans. No.	*Pages*	*Advertising*	*Place of Meeting*	*Date of Meeting*
1	—	—	Washington	July 24, 1916
2	20	—	N. Y. City	Oct. 23, 1916
3	20	—	Atlantic City	Apr. 6-7, 1917
4	14	—	Chicago	July 16-17, 1917
5	40	—	N. Y. City	Oct. 8-9, 1917
6	72	—	Rochester	Apr. 8-9, 1918
7	92	—	Cleveland	Nov. 18-20, 1918
8	88	—	Philadelphia	Apr. 14-19, 1919
9	40	—	Pittsburgh	Oct. 13-15, 1919
10	136	8	Montreal	May 9-11, 1920
11	148	16	Dayton	Oct. 11-14, 1920
12	212	13	Washington	May 9-12, 1921
13	188	12	Buffalo	Oct. 31-Nov. 3, 1921
14	214	10	Boston	May 1-4, 1922
15	187	15	Rochester	Oct. 9-12, 1922
16	352	7	Atlantic City	May 7-10, 1923
17	224	8	Ottawa	Oct. 1-4, 1923
18	—	—	Roscoe, N. Y.	May, 19-22, 1924

The Publications Committee desire to extend their hearty thanks for the valuable advice rendered the chairman by one of our former members, Mr. E. L. Bragdon, now Technical Editor of the *Radio Sun and Globe* and formerly with the *Motion Picture News*. Mr. Bragdon has been of great service to this committee and the Society.

In conclusion I desire to extend to those who will continue this work, our hearty cooperation in extending such information as they might desire.

The job is not a small one. It requires constant attention from the period that the manuscript is delivered to the Publications Committee, until the TRANSACTIONS are actually in possession of the members, in printed form, the remaining stock delivered to the Secretary, reprints sent to the authors and memorandums as to the billing, etc., forwarded the Treasurer.

Return your manuscripts promptly—make only such correction as may be necessary.

Each issue is a personal report to you of the Publications Committee.

Thanks.

O. A. GAGE
L. L. NIXON
J. H. MCNABB
J. A. SUMMER
J. C. KROESEN, *Chairman.*

REPORT OF THE PROGRESS COMMITTEE

In the compilation of the report on progress in the motion picture industry, your Committee has felt in order to be of maximum benefit to the members of the Society such a report should have two principal characteristics. First, it should be complete; second, it should be arranged in a usable form.

Its completeness depends on painstaking search of literature published for the industry and the extent to which items of progress not appearing in the leading publications are sent to the Committee. In this latter matter, we bespeak your cooperation and ask that each member of the Society make a special effort to send to any member of the Progress Committee such items covering new developments in the industry as may come to his attention. It is far better to have an item come in from more than one source than not at all.

The Committee has collected some 18 typewritten pages of material but desires to arrange it in a form which will not only make it interesting reading but will also make it suitable as a source of reference. It is the Committee's plan, accordingly, to put the report in shape for presentation at the fall meeting, making additions during the next few months.

C. E. Egeler,
Chairman.

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THE Board of Governors have selected September 29th to October 2nd, inclusive, at the Edgewater Beach Hotel, Chicago, Ill., for the Fall Convention.

The attractions offered by the hotel and the City of Chicago are too numerous to be mentioned. The Chicago Delegates are outdoing themselves for this gala event.

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OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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MEETING OF SEPTEMBER 29, 30, OCTOBER 1, 2, 1924

CHICAGO, ILL.

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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MEETING OF SEPTEMBER 29, 30, OCTOBER 1, 2, 1924
CHICAGO, ILL.

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1924-1925

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PROGRESS IN THE MOTION PICTURE INDUSTRY

1924 Report of the Progress Committee

The past year in the motion picture industry has been characterized more by improvements in processes and equipments previously available rather than by outstanding new development in the art. The advantages of standardization in other older industries are familiar to most of us; our own Society has through its active committees made excellent progress, not only in this country but by establishing relations with Europeans interested in similar work. In Germany especial effort toward the standardization of sprockets has been made[1], the Kinotechnische Gesellschaft functioning in a manner generally similar to our own Standards Committee and the English Committee on Standard Measurements.

Interest in the radio transmission of motion pictures has been accelerated by the commercial sending of still pictures by wire; at least one of our members is very active in the development of the former. The reproduction of the voice and music in synchronism with motion pictures of short lengths has been presented commercially during the past year, and a complete picture with twenty people in the cast is now being produced.[2]

As indicative of the growing appreciation of art in motion picture photography the 1923 Exhibition of the Royal Photographic Society contained a new section on cinematography.[3] An increasing use of motion pictures for the edification of employees on methods for safety is noted in this country;[4] the interest of practically all classes of people is obtained by combining these pictures with other forms of entertainment. Portable projectors enable them to be shown before groups which otherwise could not be reached.

In the preparation of this report your committee has utilized published information appearing in technical and trade publications and the monthly Abstract Bulletin of the Eastman Kodak Company, as the principal sources of the material. Some items have been included appearing outside of the calendar year, which had not previously come to the committee's attention. Information from other sources is most welcome, and if sent to the committee will assist materially in making our report complete and valuable as a source of reference.

Respectfully submitted,

C. E. Egeler, *Chairman*,
J. I. Crabtree,
Rowland Rogers,
P. R. Bassett,
J. A. Ball,
Wm. T. Braun.

[1] Kinotechnik, Oct. 1922, p. 719.
[2] Motion Picture News, Apr. 26, 1924, p. 1928.
[3] British Journal of Photography, Sept. 21 and 28, 1923, pp. 581, 601.
[4] Visual Education, April 1923, p. 108.

Cameras

A high speed camera has been built in England[5] which has a variation in speed of from 500 to 5000 pictures per second. The camera consists of a large drum about 6 feet in diameter and weighing 1000 lbs. around which a single closed loop of film, 288 pictures in length, is wrapped. An 8 hp. motor is required to drive the mechanism. The optical system consists of a ring of 40 matched lenses mounted in a rotating disc which is geared to the drum so that film and lenses pass the aperture at the same speed.

The drum is of sufficient width to take two films side by side and two rotating lens systems makes it possible to obtain stereoscopic high speed records. The whole machine weighs 4 tons; the illumination of the subjects is accomplished by the concentration of searchlight beams or magnesium flares. The apparatus is being used for scientific investigation.

A high speed camera developed at the Bureau of Standards takes pictures at the rate of 1500 per second.[6] Six lenses are employed. It is being used to study the flight of bullets and large projectiles.

As a means of doubling the field of vision a new camera[7] uses two lenses acting in the same plane embracing an angle of 60 degrees to take two adjacent close-up views. These adjacent pictures are projected to a 30-foot width screen by a twin projector.

A daylight loading camera[8] for standard film uses reels of 50-foot capacity. Focusing is accomplished by viewing a large image through a tube in the back of the camera. The full lens opening is f.2.5 and a shutter of tubular design is employed. Duraluminum is used for a camera of English manufacture[9] operated by a small electric motor which receives current from a standard storage or special portable battery. Several adjusting indicators are provided.

Among the camera attachments introduced is a focusing telescope finder [10] which gives a clear view of the entire field with a magnification of five diameters. By changing the optical system a 12-times magnification can be obtained. The images are erect and normal. Another focusing device[11] consists of a prism mounted in the camera shutter movement, and register leaf mechanism, and a special magnifier attached to the door through which the image may be clearly seen. This arrangement permits focusing directly on the subject through the film.

[5] Motion Picture News, Feb. 2, 1924, p. 536.

[6] Motion Picture News, Feb. 2, 1924, p. 536.

[7] Scientific American, Feb. 1924, p. 105.

[8] American Cinematographer, April, 1923, p. 25; Motion Picture News, Mar. 24, 1923, p. 1476.

[9] Photographic Journal (London), Feb. 1923, p. 64.

[10] American Cinematographer, Feb. 1923, p. 15.

[11] American Cinematographer, Nov. 1923, p. 23.

In addition to the cameras and projectors for non-professional use described recently in papers before the Society,[12] a new equipment[13] for amateur and home use has been introduced which weighs only 4½ pounds and which is very compact, measuring only 3×6×8 inches. It uses the 16 mm. width film from which a direct positive is made. The projector weighs 9 pounds and when folded fits into a case 8×11×11 inches in size. Illumination is furnished from a pre-adjusted, 200-watt 50-volt lamp burned in series with an air-cooled rheostat weighing only 2 ounces. Still or motion pictures may be shown. A 9 to 1 intermittent movement is employed.

Color Photography

Although a leading producer and director has recently aired his objections to colored motion pictures on the grounds of high cost, distraction from the action by the color, lack of artistic production to date, and eye strain, effort to further develop this art continues unabated,[14] and there has been marked interest during the year in both color photography and projection. Not only has there been a considerable amount of experimental work done, but some of the developments have been made available for theater projection. A five-reel feature using the Technicolor process has been widely shown during the year, and the color effects were well received by theater patrons. It is announced that other feature pictures will shortly be produced using this process. Colored inserts appeared in a number of pictures, one of which showed scenes taken under water in conjunction with the Williamson apparatus.[15]

A method of color photography recently announced[16] utilizes film embossed on the back with minute lenses. The diaphragm of the camera lens is divided into three color segments. Its principle of operation is described as follows: When the photograph is taken through the back of the film the lens elements project on the emulsion images of the three color segments. In development the positive is produced by reversal, and when the film is projected with the same three-color segment filters in the projection lens, a color picture is obtained.

Successful demonstrations have been made in England[17] of a colored motion picture method called the Cinechrome process. It is fundamentally a red-green, two color process, the two images are formed side by side on a double width film by means of a silver ruled glass grating, that part of the image falling on the silver strips being reflected and the part falling on the unsilvered strips being trans-

[12] Transactions of the Society of Motion Picture Engineers, May 7-10, 1924, p. 225 ff.
[13] American Cinematographer, Jan. 1924, p. 16.
[14] American Photography, Jan. 1923, p. 14.
[15] Motion Picture News, Feb. 23, 1924, p. 900.
[16] Science, Technique & Industries Photographique, Feb. 1923, p. 12.
[17] British Journal of Photography Colored Supplement, Feb. 1, 1924, p. 5.

mitted. The single lens takes therefore two simultaneous pictures thus eliminating parallax and color fringes. The pictures are projected at normal speed from double width positives.

A recent exhibition in England[18] of two-color films made by the C. Friese-Greene process showed in rapid motion scenes with figures, slight confusion of picture, but the color renderings of draperies were successful and essentially true. In open air views, the faulty rendering of blues of nature was reported quite noticeable. Greens and reds were excellent. Fringing effects were undetected. For the exposure, panchromatic negative stock is required costing 1½ cents per foot extra but ordinary positive stock may be used for printing; an additional operation being necessary at a cost of less than one cent per foot. The camera requires a rotating disc attachment which may be fitted into most cameras. An exposure aperture of f.8 in bright sunlight is sufficient at a speed of 22-24 pictures per second. Artificial lighting requires 15% more light than is needed for monochrome work. Development is best accomplished in darkness and printing is done on the ordinary machine, the extra processes adding a 10-15% increase in the time required for finishing.

Condensing Lenses

Of especial interest in connection with improvement in condensing lenses, as well as for other use, is the announcement[19] of the commercial development of clear fused quartz. The very low temperature-expansion coefficient permits this material to be subjected to quick temperature changes without cracking; quartz condensing lenses used with the high intensity arc lamps show no breakage even after several months use. The low light absorption of quartz (about 1/5 that of glass), the low expansion and contraction (1/16 that of platinum), and its ability to pass ultraviolet light, are its important characteristics.

Educational

Complete and detailed studies in the projection of light have been published[20] during the year in the form of a series of articles by a well known engineer and physicist. These cover light reflection from spherical, parabolic and other polished surfaces, as well as refraction by lenses, for different types of light sources.

Film

The use of direct positives as a means of reducing the cost of motion picture projection for the amateur has been discussed before the Society,[21] and general interest obtains in this process abroad as

[18] British Journal of Photography Colored Supplement, Apr. 4, 1924, p. 16.
[19] Light, July 1924, p. 6, Motion Picture News. May 24, 1924, p. 2528.
[20] General Electric Review, Feb. 1923, and issues following.
[21] Transactions of the Society of Motion Picture Engineers, May 7-10, 1923, p. 246.

well as in this country. Experiments[22] on a reversal process for film conducted at the Technical High School for Photography at Munich employ positive stock exposed ten times normal (1/35 of a second at f.1.4). The exposed film is developed in a caustic soda pyrocatechol developer, bathed in a sodium sulfite solution, bleached in an acid permanganate solution and cleaned in sodium bi-sulfite. After hardening in a plain chrome-alum bath the film is redeveloped in a weak metol-hydro quinone developer in strong light. Another German reversal film and process produces either black and white or brown-tone positives.

In France direct positives for amateur projectors have been made[23] by employing positive film, using very large aperture lenses. In sunshine an aperture of f.6 was necessary. On cloudy days f.2.5 apertures are reported to give good results. The thin evenly coated film employed is given a special chemical treatment. Another direct process[24] recently marketed uses an outfit consisting of a light weight motion picture camera and tripod, film frames, frame holder, for film winding, developing and washing, and other accessories. The entire operation is adapted to standard cameras.

For the preservation of film a liquid wax[25] has been introduced, for which both renovating and sprocket holes waxing advantages are claimed. Another German process[26] is claimed to eliminate film scratches. Still another process has also been introduced which may be attached to any standard projector.[27]

Announcement was made in England of a new motion picture negative emulsion[28] which yields strong contrast and has an average gamma infinity value of 4.0.

General

When the necessary precautions are used successful motion pictures can be obtained in the Arctic regions at temperatures as low as 65 degrees Centigrade below zero.[29]

An electrically operated orchestra director has been developed which automatically signals to the conductor those things he should know to synchronize the music with the projected picture.[30] Should the film break, the apparatus automatically stops. A principal advantage claimed is that it is not necessary for the director to keep shifting his eyes from the music stand to the picture.

[22] Kinotechnik, May 25, 1923, p. 264; Oct. 20, 1923, p. 477.
[23] Bulletin de la societe francaise de photographie, Sept. 1922, p. 261.
[24] Kinematographic Weekly Supplement, Dec. 7, 1922, p. iii.
[25] Motion Picture News, May 31, 1924, p. 2702.
[26] Motion Picture News, July 5, 1924, p. 108.
[27] Motion Picture News, Jan. 16, 1924, p. 774.
[28] Photographic Journal, April 1924, p. 188.
[29] American Cinematographer, Aug. 1923, p. 8.
[30] Motion Picture News, Feb. 9, 1924, p. 671.

Illuminants

The past year has shown increasing interest in the development and use of reflector arcs. While this development is not as active here as it is abroad, there are several types of reflector lamps on the market. Experience has shown that automatic control is essential for these units and several such controls have been developed, some working on the constant feed principle and others using arc voltage control. The proper field for these lamps is still indefinite, but their most efficient operation appears to be in the small and medium sized theaters, for which material savings in current are claimed in comparison with the use of standard types of arc lamps. There are several types of these lamps on the market in England, Germany and other European countries. To obtain closer current regulation than is possible with the average resistance, a vernier tandem unit is advocated for use with these arcs.[31]

These reflector lamps are essentially low current units operating at from 15 to 25 amperes. Carbons are ordinarily mounted in the optical axis, the negative carbon passing through the center of the reflector. No condensers are ordinarily used, the light by the projector being directed to the film and objective lens. One exception is a unit developed in Germany which uses a large mirror in conjunction wtih a single plano-convex condensing lens.[32]

In this country the incandescent lamp projecting systems are being employed in increasing numbers. The aspheric condensing lens systems[33] are now generally employed, the increased amounts of light obtained with them having extended their field of application to all except the largest theaters.

A rotary arc lamp for motion picture projection has been tried out in a London theater.[34] This arc lamp contains an annular water-cooled negative electrode of copper. The positive carbon is held centrally in the hole of the annular negative. Magnetic flux across the arc causes the negative spot to whirl rapidly around on the inner edge of the negative ring but the crater face remains steadily illuminated and entirely unobstructed by any negative shadow. As there is no negative carbon, the lamp house and lens holder can be made very compact.

It has been reported that more rapid deterioration of the film has been experienced with the reflector arc lamp, and investigations have been conducted in Germany[35] on the relation between temper-

[31] Kinematographic Weekly, Dec. 13, 1923, p. 70.

[32] Moving Picture World, Aug. 18, 1923, p. 589, Aug. 25, 1923, p. 672. Motion Picture News, Aug. 18, 1923, p. 809, Kinematographic Weekly, Sup. Nov. 9, 1922, p. 4, and Dec. 14, 1922, p. 4. Motion Picture News, Mar. 22, 1924, p. 1354.

[33] Transactions of the Society of Motion Picture Engineers, May 1-4, 1922, p. 80, and Oct. 1-4, 1923, p. 126.

[34] Kinematograph Weekly. Sept. 15, 1922.

[35] Kinotechnik, April 14, 1923, p. 175.

ature and illumination at the aperture for condenser and reflector arc lamps; both a platinum bolometer and a thermocouple were utilized with reported accuracies of plus or minus two percent. The relations between current consumption, screen brightness and temperature of the film gate were made available in graphical form. The opinion has been advanced from another source that ultra-violet light reaching the film may be an important factor.

Laboratory Practice and Apparatus

A density meter has been developed[36] which makes use of the photometric cell instead of the eye for reading the opacity of a silver deposit. The device utilizes the principle of subjecting the cell alternately to two beams of light, one having passed through the medium whose opacity is required and the other through a standard optical wedge whose position is so adjusted, that the photoelectric current remains unchanged during the substitution of one beam for another, to avoid the inconsistent behavior of the selenium cell.

A new film splicing machine[37] has a cutter, scraper and joiner on one base plate. A single down stroke of the lever serves to cut and scrape the film. When the lever is pressed down only half way the film is cut without being scraped. Another machine[38] for developing, fixing, washing, tinting, drying and polishing either negative or positive film, is used in Germany. The machine has a capacity of 20,000 feet of film per day and requires only two men to operate.

A portable motion picture finishing apparatus[39] has been developed which fits into a case less than three feet square when packed for shipment. The apparatus apparently consists of an apron for winding the film in the form of a spiral and a number of shallow circular tanks for containing the solutions. A similar apparatus was developed in this country in 1918.

Lighting

Japanese advices report Professor Kyogi Suyehito of Tokio Imperial University has perfected a new method of taking flashlights of very short duration under water for still or motion pictures.[40] By the new Japanese process mercury is drawn through a hair-fine bore of a glass tube, serving the same purpose as the filament of the modern lamp. When a low voltage is turned on, the mercury is heated to the explosion point almost instantaneously, and as the tube bursts a brilliant mercury arc light is produced for a fraction of a second or so, then dies. Instantaneous photography of mental vibrations, rolling of model ship hulls from beneath the surface of water in tanks,

[36] Photographic Journal, April 1924, p. 189.
[37] Kinematographic Weekly Supplement, Nov. 30, 1922, p. v.
[38] Motion Picture News, Dec. 9, 1922, p. 2958.
[39] Kinematographic Weekly, Mar. 20, 1924, p. 76.
British Journal of Photography, 65; 379, 1918.
[40] Motion Picture News, Nov. 10, 1923, p. 2284.

etc., etc., are predicted as possible under better result producing conditions by this Japanese scientist's invention.

A new lighting unit for studios has been developed and has given excellent results in diffused lighting. This unit[41] consists of a high intensity arc mounted in the center of a large 5-foot faceted concave reflector. The reflector has a diffusing surface of a special material which is designed to prevent eye burn and the unit though powerful has proven useful and comfortable in the studios. The high intensity arc has also appeared in the studio in a smaller form than the original 150-ampere studio lamp. It is much more actinic than the ordinary carbon arc spotlight.

Announcement has been made of the development of another system of studio light control. A one-switch control makes it possible for one man to control all the lights on a set through one portable switch box located near the camera.

Projectors

An automatic projector has been introduced in England for the projection of one-thousand-foot reels of film.[42] In appearance the unit resembles a grandfather's clock with the picture showing where the clock face would ordinarily be. After projection of the film, which occupies about twenty minutes, rewinding is accomplished in about three minutes while a still picture is shown. It is expected that the device will be used largely for advertising purposes. Another projector of English design uses a 2-blade flat disc shutter between the aperture and condenser close to the film at the gate.

A new intermittent movement design[43] embodies an improved lubricating system, a more convenient method of adjustment, and a double bearing on the intermittent shaft. Another design uses the three-branched Maltese Cross principle; it is claimed that from 40 to 75 percent increase in screen illumination can be obtained and that so-called scintillation is materially reduced. Change in the shutter design is necessary. Flicker elimination is the objective sought by a German inventor who moves the light beam in synchronism with the film.[44]

A continuous projector[45] recently announced utilizes a revolving ring of lenses and a second fixed system of lenses the middle ring of which is in optical connection with the projector lens outside of the ring. The film moves continuously in step with the revolving ring of lenses. It is said that flicker is absent even at a projection speed of two or three pictures per second.

[41] Motion Picture News, Sept. 15, 1923.
[42] New York Tribune, Apr. 7, 1924.
[43] Motion Picture News, June 20, 1924, p. 3112, and Moving Picture World, June 20, 1924, p. 847.
[44] Scientific American, Jan. 1923, p. 29.
[45] The American Photographer, Jan. 1924, p. 38.

In Germany interest has recently been shown in the measurement and elimination of excess heat at the film gate.[46] A specially devised film gate employs a fluid cell containing water or a solution. The formation of bubbles is prevented by cooling by means of the pipe in the cell through which water is circulated. It is claimed that with arc lamps the film could be stopped for still projection without burning the film. A blower system has also been employed to keep the cell solution cool. With projectors employing incandescent lamps the introduction of an air current between the lamp and condenser is proposed to reduce the heat reaching the film and condenser lens.[47] A thin piece of transparent mica inserted between the light source and condenser or fused silica glass, are also suggested, but forced ventilation is an essential feature.

A new film rewinder[48] employs 6-inch diameter hubs which are used in both the feed and take-up boxes. The upper box is horizontal, with a rotating booth, and the film feeds from the inside roll to the upper sprocket by a centrifugal pressure; the speed of the rotating feed plate is controlled by means of a revolving helix acting on a friction disc. After projection the large core of the lower roll is removed and the entire roll transferred to the upper box. A new nonrewinding magazine has been developed in this country, which may be attached to any standard projector.[49]

A safety device designed to prevent burning of the film whenever the film breaks or is burned out at the gate, drops a shutter directly in front of the film gate and at the same time stops the motor. It also functions should the film loops become shortened due to stripped holes.[50]

Special Effects

In order to effect saving and production costs a device has been perfected for making realistic night scenes in the daytime. This device consists of an attachment for any standard make of camera, used in conjunction with a special coloring solution with which the finished negative is treated.[51] Although no particulars are given the method undoubtedly consists of photographing through a red filter on to a panchromatic emulsion sensitive to infra red. Such emulsions can be prepared by bathing in dicyanin, kryptocyanin, etc.

Statistics

A comparison of the number of motion picture theaters in the British Isles with those in the United States shows that this country has considerably more in proportion to the population. For the generally accepted figure of about 14,000 theaters in the United

[46] Kinotechnik, Feb. 20, 1924, p. 39.
[47] Kinematographic Weekly, Jan. 18, 1923, p. iv.
[48] Kinematographic Weekly Supplement, April 19, 1923, p. iv.
[49] Motion Picture News, Jan. 16, 1924, p. 774.
[50] Motion Picture News, Nov. 18, 1922, p. 2576.
[51] American Cinematographer, Nov. 1923, p. 5.

States there is in this country one theater for every 8,000 people. There are 40,073 motion picture theaters in the British Isles, one for every 11,009 people. London with a population of over 700,400 has only 385 theaters, or one for every 18,200 people.[52]

A very extensive survey[53] of the motion picture industry has been conducted by the Babson Statistical Organization; Rowland Rogers, head of the department of Photoplay Production of Columbia University; and the editor of Motion Picture News. Calculations have been made on the basis of 14,000 exhibitors. Three articles giving the results of the survey were published; the first contains statistics covering the size of theaters and number of days a week open, number of employes, and prices of admission. The second article gives information concerning the program, the number of reels per program, the character of the program besides the feature picture, kind of music, etc. The third article contains a percentage expression of the answers to a question relating to present business of the exhibitor compared to past, seasonal receipts, opinions on foreign films and the influence of varying feature pictures on the attendance.

Figures published for 1921 give the number of establishments engaged in the production of motion pictures in the United States as 127, employing 10,659 persons, whose product is valued at $77,397,000.[54]

Figures for the year ending March 1923 show that only about two-thirds of the footage of unexposed negative was imported in 1923 when it was dutiable as compared to the year ending March 1922 when it came in duty free. The values of cameras imported[55] almost doubled for 1923.

Stereoscopic Projection

Efforts to obtain stereoscopic motion pictures have claimed the attention of a number of inventors and others in the industry. One director it is reported is making a feature picture using a camera of English development for which stereoscopic effect is claimed.[56] A new projector for theaters[57] uses a film made from a negative taken with a camera containing two lenses the same distance apart as the average human eye. The two pictures are projected alternately and rapidly on a screen with a double projector. Viewing is accomplished by means of a small apparatus placed in front of each spectator which consists of a circular aluminum casing inside of which a motor driven fan blade rotates at 1500 r.p.m. in synchronism with the shutter blades of the projector. Another device uses two lanterns with an oscillating shutter, the pictures being viewed through corresponding

[52] Motion Picture News, Nov. 24, 1923, p. 2444.
[53] Motion Picture News, Nov. 18, Nov. 25, and Dec. 2, 1922, pp. 2527, 2644, 2772.
[54] Motion Picture World, Dec. 23, 1922, p. 715.
[55] Motion Picture News, Aug. 25, 1923, p. 926.
[56] Motion Picture News, July 26, 1924.
[57] Scientific American, Jan. 1923, p. 5.
Motion Picture News, Nov. 18, 1922, p. 2574.

synchronous shutters. A new adaptation of the anaglyphic method of viewing is also reported[58]; no special eyeglasses are used.

Still another method of projecting stereoscopic motion pictures comprises, (1) a special camera using film on which the individual pictures are twice as wide and one and one-half times as high as those on standard film; (2) a special projector, and screen, the latter is $21\frac{1}{2} \times 40$ feet in size, in front of which is strung a "breaking surface" compound of several miles of thread. This breaking surface is claimed to give relief to the pictures and to avoid angular distortion. All prints are to be made by projection.

Studio Practice

Among the new lighting units developed for studio lighting is an arc lamp spotlight which has as its principal feature an adjustable device to regulate the feeding of the carbons.[59] The positive carbon is rotated at two revolutions per minute. A high current, high intensity arc lamp[60] for studio use produces a maximum candlepower of 100,000 or sixteen times that of the ordinary flaming arc.

Clay figures as actors for animated cartoon photography have been employed.[61] Blue clay, free from gloss and not too wet, has been found best for this work.

Flat white and aluminum painted reflectors are generally used for the control of shadows in both studio and outdoor photography. A new reflector[62] has been introduced in England which is prepared by coating a corrugated cardboard with silver foil covered with a transparent air proof varnish. High efficiency and lack of the objectionable features of metal mirrors are claimed for the reflector.

An innovation in motion picture photography that is expected to create considerable interest has been introduced in a recent production.[63] The new method was used in the lavish cabaret scenes, which had a water landscape in the background. In the foreground was a scrim stretched taut across the dancing floor. Upon this netting was painted a deep sea scene in rich colors. When the powerful studio lights were leveled on the scrim, the background of the set was blotted out. When these front lights went out the dance hall came into view, the floor being seen for the first time. When these lights went out the dancers were in silhouette, and the backdrop appeared to be pushed miles and miles away. The result was an interesting study in perspective and composition.

Another development has been made for this same purpose which recently has proved very successful. This consists in the actual

[58] American Photographer, June 1924, p. 382.
Bulletin de la Societe Francaise d'Photographie, Sept. 1923, p. 261.
[59] American Cinematographer, July 1923, p. 13.
[60] American Cinematographer, April 1923, p. 14.
[61] American Cinematographer, June 1923, p. 7.
[62] Kinematographic Weekly Sup. Dec. 14, 1922, p. iii.
[63] Motion Picture News, Sept. 15, 1923, p. 1356.

construction of the upper parts of the set in miniature and placing them nearer the camera than the full lower portion of the set. This has not yet been used to much extent but in certain cases has proven deserving of more attention and development One excellent example was the miniature of an elaborate cathedral ceiling with carved vaulting and pendants.

The use of a 90-foot steel boom with the camera platform constructed at its extremity is an innovation in filming large sets from almost any position in three dimensions.[64]

A new method of taking close-ups during production has been successfully developed in a California studio. The method consists in equipping an extra camera with a special wide angle telescopic lens so that the camera may be set at the same distance from the set as the regular camera which is recording the normal action. These close-up shots not only save time in being taken simultaneously with the normal, but also give perfect continuity of action and expression when cutting from one to the other.

The technique and use of "glass work" is becoming rapidly improved and more widespread in studios in this country, both in the east and west. The "glass work" consists in photographing a scene through a large piece of plate glass some distance in front of the camera. The lower portion of the scene in which all action occurs is constructed as a set in the studio. The upper portion of the scene is painted on the plate glass so that through the camera lens the painted portion is accurately superimposed on the true set and the division is not apparent. A fine example of this work is the Notre Dame cathedral in the picture of "The Hunchback of Notre Dame." This development is greatly enhancing the apparent size and grandeur of studio sets and will probably be used to even greater extent in the future.

A novel method of obtaining wave motion effects for close-ups in ship-board sets has been devised. It consists of a universally pivotted lever mounted low on a floor stand. One leg of the camera tripod is set into the short arm of the lever. The long arm of the lever is then moved up and down and sideways by hand, thus twisting and raising and lowering the camera to simulate wave action.

Talking Motion Pictures

In addition to the De Forrest and Tykociner methods for reproducing the voice or music in synchronism with the projection of pictures which have been described in papers read before the Society[65] other methods introduced include an apparatus,[66] the operation of which is described as follows:

Light from an arc or gas-filled electric lamp is sent toward two

[64] Scientific American, March 1924. p. 169.

[65] Society of Motion Picture Engineers Transactions, May 7-10, 1923, pp. 61, 78 and 90.

[66] Exhibitors Herald, April 14, 1923, p. 87.

discs revolving in opposite directions; the first disc has a series of holes along its edge, each of which transmits a strip of the image while the second disc has a serrated edge formed of spokes which receives the light from the first disc, and passes it in flashes of audible frequency which are focused on a light sensitive selenium cell. The serrated disc overcomes the lag difficulties of the cell. Amplification and transmission of the impulses is then accomplished in the usual way. A similar double disc arrangement is used for the receiver except that a series of quick acting lamps wired to a commutator replace the holes in the sending set disc.

Another device[67] employs a recording instrument which uses a special Nernst filament lamp as its amplifier. The sound record is made on the edge of the film and reproduction is accomplished through the use of a potassium photoelectric cell. Still another scheme[68] records the sounds to be reproduced on a series of phonographic records. These are reproduced by a special phonograph perfectly synchronized with the projected picture.

Among other developments[69] an apparatus known as the pallophotophone designed to produce reproductions of the voice and music recorded in conjunction with motion pictures operates on the same general principles as do the DeForest and other systems. Demonstrations have been also made of still another development[70] for which simplicity of apparatus is claimed.

[67] British Journal of Photography, May 25, 1923, p. 319.
[68] Motion Picture News, Dec. 1, 1923, p. 2608.
[69] Journal of the American Institute of Electrical Engineers, May 1923, p. 520.
[70] Motion Picture News, March 8, 1924, p. 1122.

DISCUSSION

Mr Porter: It seems to me that the Report of the Progress Committee is not only one of the most interesting but also one of the most valuable that has ever been presented to our Society. The Society is to be congratulated on having such a report, and I hope every effort will be made to continue it at each future meeting. It illustrates exceedingly well the advantage which could be obtained if our papers could be printed in advance. If we had had this Report in advance, undoubtedly there are men here who could discuss it, and I think every effort should be made to send out such a report at least a day in advance of its reading.

President Jones: I am particularly interested to get some expression of opinion from the Society with regard to a report of this kind. I feel more or less responsible for its preparation, since I requested permission to reappoint this Committee after it had been discontinued by action of the Board of Governors.

I might explain a little about the history of the case. The Illuminating Engineering Society have published annually such a report as this for several years past. This report usually contains 300 or 400 references to the literature which has appeared, and I have found the report of immense value since it is only necessary to go to it to find what has been done in any field of illuminating engineering. I think a digest of a similar type would be of immense value to members of our organization. Frequently, we wish to look up a subject, for instance, on high speed cameras, and if a report of this kind is available, it can be done in much less time than it would require to go into the literature and find it. I realize that it is desirable to reduce publication costs to a minimum, but I believe a report of this kind is worth publication and I should like to get an expression of feeling from the members as to what our policy should be in the future in continuing to have a Progress Report either semi-annually or annually.

Mr Roebuck: I appreciate that report, and I believe it would be highly desirable to have it twice a year, and to have it published in advance of the meeting if possible.

Mr Powrie: I think it would be well if members who may be in possession of information which might be included in a report of that kind would contribute it and try to furnish statistics, information, and improvements relating to the industry.

Mr Renwick: I think everything depends on the man who writes the report. On this particular occasion we have been able to get an excellent report through the influence of our President, and I hope it will be continued.

Mr Stark: I would point out that a Progress Report is a very desirable thing if it reports progress. I have read several reports of

the Progress Committee of the Illuminating Engineering Society in which some things reported were not progress although the statements were published in some paper. The apparatus would not work. This is especially true in the motion picture industry with regard to stereoscopic projection. There are scores of articles describing devices for stereoscopic projection which might be classed as progress but do not work.

Mr Richardson: In my opinion, many of the things which do not represent direct progress nevertheless lead to real progress, and certainly such things ought to form a part of the Progress report even though they may show we are not progressing but indicate avenues along which progress might be made.

Mr Theiss: I have heard it said that the most valuable thing in Edison's library is a book on things that won't work, and I think that is particularly valuable information to have.

President Jones: Perhaps the word "progress" is a misnomer; however, I think the report as submitted is ideal and very near to my idea of what we should have. The point which Mr Theiss brought up is very valuable; a man looking up the literature is just as anxious to find those schemes which will not work as those which will It is quite impossible to expect any one man to examine all the subject matter critically. If the Chairman of the Progress Committee has to be responsible for what is in the papers which he abstracts, you cannot get any one man to do it. What we want is some one who will spend the time, who will keep in touch with all the material appearing in the current literature, make brief abstracts, and give us classified references. To me that is the ideal type of report. Perhaps it is not progress, but I feel that the type of report Mr Egeler prepared is what we need, and I think we owe Mr Egeler and his associates a vote of thanks for the time they have put in.

Voice: It is too much for one man to gather such information and why wouldn't it be a good idea to ask each man for what he knows is progress during the year. I believe each member could bring in additional data that should be included.

President Jones: That is an excellent idea but it does not work. We have tried it. I think Mr. Little could speak from experience on this subject, and Mr. Egeler also. We have suggested repeatedly that members send in material but they do not do it. A committee is appointed and, as a rule the chairman does most of the work. Mr. Egeler has had three other men on his committee and I happen to know in this particular case that some of the members have given him material assistance. Your suggestion that all members of the Society contribute to the Progress Report is excellent in theory but it certainly does not work out in practice because I know that Mr. Little, when he was chairman of this committee, appealed repeatedly to the members for suggestions. I believe the returns were practically negligible. The preparation of a Progress Report is practically a one-man job since it is almost impossible to persuade

the members as a whole to contribute. This is, of course, to be deplored for the members of the Society are in touch with more developments than any single individual can hope to be and if they would forward to the chairman of the Progress Committee information in regard to these developments, the work of preparing the Progress Report would be ever so much less and a better and more complete report could be written. It really would take only a few minutes for each one of you to send in helpful suggestions to the chairman of the Progress Committee and I should like again to urge you to keep this in mind during the coming months.

Mr. Little: The Progress Committee, when I was its Chairman, was composed of the chairmen of the standing committees and at that time I believe there were thirteen committees. Letters sent to the members of the committee asking for information rarely brought any response. Meetings which were called at infrequent intervals though rather poorly attended brought forth considerable information.

President Jones: I think as a result of the expressions of opinion that we should feel justified in continuing this work, and I think probably this will be done.

THE FOREIGN SITUATION

By Joseph Dannenberg*

AMERICA stands supreme in the production of motion pictures. Whether this supremacy will be retained is, of course, a matter for future decision. There is, however, nothing in sight to indicate in the slightest degree any offset to existing conditions.

The Great War naturally retarded the development of the industry, not only in all of Continental Europe but in England as well. During the period of the war, and the re-adjustment period following, the industry in America went forward with great strides.

There is a dirth, however, of ideas and equipment of vital essentials in foreign studios and these are most essential to the makings of such pictures as will naturally compete with the product of American studios.

At the present moment Germany stands forward as probably the most important producing center across the water. In Germany there is not only a marked activity but a very definite intention to produce pictures for the world market. The U.F.A. Organization has made "Siegfried" based upon Sagas of the Ring of Niebelungen. There are many in America who are familiar with Wagner's magnificent opera and will recall this story. "Siegfried" is one of the very finest pictures ever made. Whether or not a story which is as tragic as this will appeal to the great masses of theatre-goers here remains to be seen. There is no doubt whatsoever of its tremendous value as a great and masterful production. It is my understanding that U.F.A. intends to continue with this type of product in an effort to supply the world market. They have just completed "Faust" with Emil Jannings, a most sterling actor, as Mephisto. It will be recalled that several important American producers including Mary Pickford and D. W. Griffith contemplated producing "Faust."

Not only is this type of material forthcoming from Germany but it is my further understanding that U.F.A. intends to produce stories with International flavor. That is to say not only American but English actors and directors will be used.

There was recently brought to America by Herbert and Charles Wilcox of the Graham Wilcox Productions of London, the picture "Decameron Nights" based on the tales of Boccaccio and which as a play enjoyed a successful run at the Drury Lane Theatre, London. In this production Charles Wilcox has used Lionel Barrymore, an outstanding figure on the American screen and Ivy Duke, an outstanding figure on the English screen. Werner Krauss, one of the greatest actors of the day, whose successes not only in Germany but also in America have made him famous, appears in this production.

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He appeared last year at the Century Theatre in Max Rheinhardt's production of "The Miracle", and added to his laurels. This Graham-Wilcox production was made in the U.F.A. Studios outside of Berlin and gives a very clear indication of the purpose and plans of the films with International flavor that U.F.A. intends to develop.

There are other German concerns not as large nor as important as U.F.A. but who are moving rapidly in an effort to obtain a showing of their productions in the world's market.

It is to be regretted that the remainder of Europe including England does not seem to be stepping forward in the same manner. There was recently shown an Italian picture produced by Enrico Guazzoni called "Messalina." There were some big and important sets but that is about all.

France shows little progress in the way of motion picture productions. The equipment in French Studios up to last year has been most unsatisfactory. The same condition exists generally throughout Europe excepting Germany. As an example: when Metro-Goldwyn's "Ben Hur" was slated for production in Rome it was necessary to construct a special studio with a stage sufficiently large because there was no stage in Rome over 50×100. There was no lighting equipment in Rome sufficiently strong enough to make a picture of the size of "Ben Hur." The plant had to be assembled, the component parts coming chiefly from Germany.

In England due to a variety of conditions, production during 1924 reached its lowest ebb. In August when I was in London there were few concerns actively producing. They were Stolls Ltd., Bromhead, Gaumont and Graham Wilcox. There were several small, unimportant concerns producing unimportant pictures, both features and short subjects, but not the type of pictures which might reach the world market.

There had been several failures of producers and distributors in England during the period of six months prior to my visit. Because of existing conditions they would have failed in any country at any time. In other words their product was not what is considered salable. They did not fail because they were located in England, they would have failed in America as well. This is briefly the situation in Europe.

It is very difficult, if not impossible, to give an accurate idea of what is occurring in the way of picture production in Russia. When one visits the leading studios of Russia the producing situation is such that one hesitates to accept as facts the statements made. Briefly speaking, however, there is no likelihood of Russia becoming an important center of motion pictures for some years to come. Such productions that are made are nothing but propaganda for the Soviet Government.

THE EFFECTS OF NON-STANDARDISATION OF PROJECTION MACHINES

By W. C. Vinten*

ENGLAND'S being a so-called free trade country, we receive and use a large proportion of imported projectors, some manufactured under metre and some under standard dimensions. The first defect discovered by the exhibitor or his operator is that the spool spindles only accommodate spools made for, or by, the same manufacturer, and if the installation has machines of different makes, the operator has to see that film reels 1, 3 and 5 are on one type of spool, and reels 2, 4 and 6 on the other. He also requires two rewinders accommodate same, or must have the spool spindles altered on one of the machines to match the other, which is the usual course adopted.

Five years ago the Standards Committee of the Incorporated Association of Kinematograph Manufacturers of Great Britain set up a standard spindle and driving pin, and all British machines now comply with this; the Pathe 10 mm. is so near as to come within the limits; the Gaumont machine has been altered to suit, and the important German makes also come within the limits. The Nicholas Power machines conform to the same standard and the only serious outstanding make is the Simplex projector with its 5/16″ spindle and key, and its large diameter core to the spool.

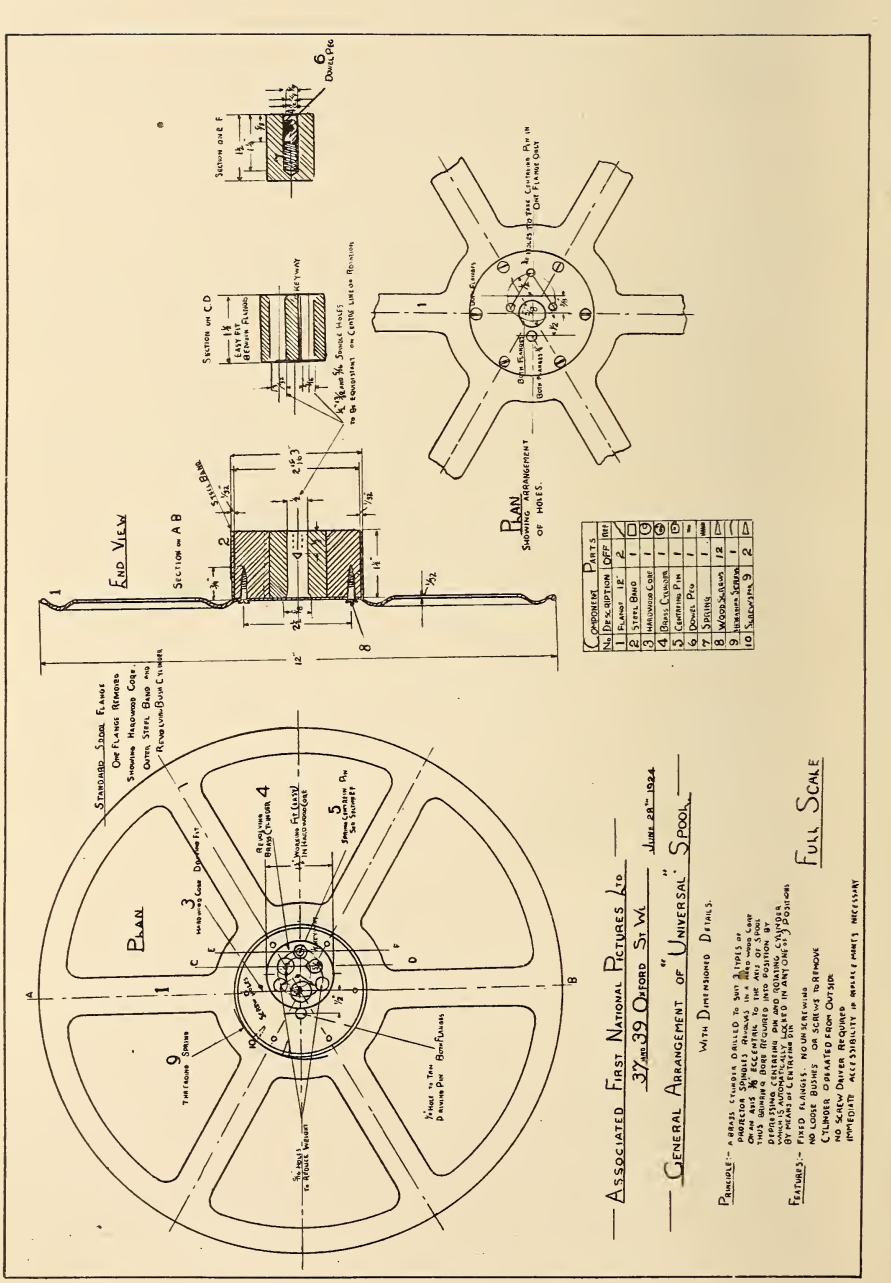
I feel sure that Mr. Porter of the Precision Machine Co. and your Standards Committee would make a move in this direction if I could only express the amount of bad words and the good money that are wasted through its not receiving the attention it should have.

Film spools are universally accepted as the correct means of supporting and controlling films on projectors, therefore why should not the spindles and driving pin that support them be universal.

The film tin now used for transport is not ideal as a means of support to the film, and it has long been realized that the spool should be used in the transit case, as it is the ideal way of supporting a film, and several rewindings would be dispensed with if the exhibitor which received the films were on reels that could go direct on the machine, and the films returned also on the spool ready for inspection by the renter.

Several renters have approached me on the matter, but when I pointed out the variations of projectors, it has been turned down until machines become standard. Five years have elapsed and we are still without this important standard's being adopted. Mr. C. B.

* Engineer, London, England.


Associated First National Pictures Ltd
37 and 39 Oxford St W.
June 28th 1924
General Arrangement of "Universal" Spool
With Dimensioned Details.
Full Scale
Plan
End View
Section on A B
Section on C D
Section on E F
Plan
Showing Arrangement of Holes.
Standard Spool Flange
One Flange Removed
Showing Hardwood Core.
Outer Steel Band and
Revolving Brass Cylinder
Revolving Brass Cylinder
Spring Centrifugal Pin
Sub Sliding Pin
Thrust Spring
Bottom Flanges
Dowel Peg
Keyway
Steel Band
Bottom Flanges
Component Parts
No. Description Off Ref
1 Flange 12" 2
2 Steel Band 1
3 Hardwood Core 1
4 Brass Cylinder 1
5 Centrifugal Pin 1
6 Dowel Peg 1
7 Spring 1
8 Wood Screws 12
9 Screwing Screws 1
10 Screwing Screws 2

Hogg, Assistant Sales Manager of First National Pictures Limited of England, approached me on the matter twelve months ago, but owing to the difficulty mentioned, allowed it to stand over. But it was felt that the matter was so pressing that he designed and patented a spool whereby he obtained the necessary sized holes for all machines by means of an eccentric drum inside the spool centre, and same was demonstrated at the Firm's Annual Convention in August last and approved, and a quantity are now being made up in my Works to see how this interesting experiment turns out. This firm is giving the benefit of this spool to all renters on payment of a small royalty to Mr. Hogg, such royalty being included in the purchase price of the spool.

Here we have another case of the use of brains and money in getting round an evil that should not exist, and this is not helping forward standardisation but tending to defeat it. Messrs. Kodak's new positive perforation is the other instance, the hole being made .005″ wider to meet the interference caused to the sprocket holes by manufacturers sprockets not being standard, and universal standardisation is again made more remote by another step in the wrong direction, due to engineers of the industry not adopting and working to universal standards. I, therefore, as one of these engineers, repeat what I stated in a paper read by me at your last Convention, the necessity of the British, American and German Standardisation Committees getting together and fixing definite standards, so that brains and money will be used, not in a backward movement, but in a forward one.

INVESTIGATIONS ON PHOTOGRAPHIC DEVELOPERS

Sulphide Fog by Bacteria in Motion Picture Developers[1]

By Merle L. Dundon and J. I. Crabtree

I. Facts which Led to this Investigation

1. A tank of MQ developer, used for the development of motion picture negative film suddenly began to give excessive fog. The developer had been in use for about six weeks in a 65 gallon soapstone tank but had not developed its normal footage of film (about 500 feet per gallon). The next lot of developer in the same tank gave excessive fog after three weeks use when 5000 feet of film had been developed. The solution smelled badly and the odor of hydrogen sulphide was distinguishable. Further tests, as described later, confirmed the presence of sulphide.

2. A four liter sample of MQ tank developer, which had been in use for one week, and which did not then give fog, had been kept in a closed bottle for about four months. When examined, it was found to give intense fog and to contain sulphide.

3. A tank of No. 16[2] motion picture positive developer started to fog when two weeks old and only partially exhausted. A sample of this developer was placed in a closed bottle and when examined four months later was found to contain a considerable quantity of sulphide.

4. The same trouble with fog also occurred in a film developing machine where the developer was kept in long glass tubes set in a hard rubber base. The tubes were fastened to the base with a pitch cement around a soft rubber washer. The pitch was tested and found to be free from sulphur. In this case a heavy sludge found in the bottom of the tubes was identified as silver sulphide.

All the developers mentioned above had been used, and the generation of sulphide has not been observed in unused developers. Moreover, in all the above cases the developing solutions had been standing unused for at least two or three days just previous to the time when their fogging action appeared.

II. Methods of Detecting Sulphide in Developers

1. If a drop of lead acetate solution is added to a developer containing sulphide a brownish-black precipitate of lead sulphide is formed. If sulphide is absent a white precipitate of lead carbonate and sulphite is obtained. A sufficiently small amount of lead must

[1] Communication No. 218 from the Research Laboratory of the Eastman Kodak Co.

[2] Manufacturers' recommended developer for Eastman Positive Motion Picture film.

be added so that a slight precipitate of lead sulphide will not be hidden by a large amount of white precipitate.

2. A piece of filter paper wet with lead acetate is covered with a black silvery deposit of lead sulphide when exposed to hydrogen sulphide gas. Such a test can be made by hanging a lead acetate paper in the top of the bottle nearly filled with the solution to be tested. When the solution is distinctly alkaline, as with most developers, the amount of hydrogen sulphide which escapes is very small. In such cases it is sometimes necessary to make the solution acid with hydrochloric acid and warm gently, holding the lead acetate paper in the escaping gas.

3. When cadmium chloride is added to a developer, white cadmium hydroxide is formed, but if sulphide is present a yellow precipitate of cadmium sulphide is also obtained. On adding ammonium hydroxide the cadmium hydroxide dissolves leaving a suspension of yellow cadmium sulphide which gradually settles out as a flocculent precipitate. This test is quite sensitive if the developing solution itself is not yellow.

III. The Concentration of Sulphide and the Extent of Fog

1. The concentration of sulphide in the fogging developer was determined photographically as follows:

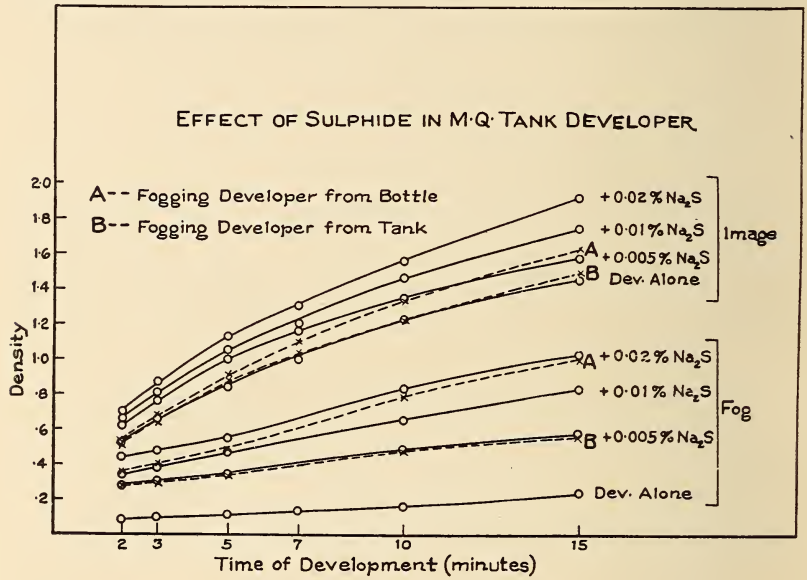
Definite amounts of sodium sulphide were added to samples of a used MQ tank developer and strips of NC film, on part of which a definite exposure was made, were developed in these solutions. The fog on these strips was then compared with that produced by the fogging developer under the same development conditions. The results are shown by the accompanying curves. The upper set of curves represents the growth of image density with time of development while the lower set represents the corresponding fog densities. The dotted lines represents the fogging developers of unknown sulphide concentration. From these curves it is evident that the fogging developer taken from the tank contained sodium sulphide in a concentration of about 0.005%, and that which spoiled in the bottle contained slightly less than 0.02%. Also the magnitude of the fog values show how small a quantity of sulphide is required to produce serious fog.

IV. Possible Sources of Sulphur in Developers

Having established definitely the presence of sulphide in developers, the various possible sources from which it might come were considered and investigated as described below.

1. *Hypo.* In tank development where wooden racks carrying the film are passed repeatedly through the developer, fixing bath, and wash tanks, it is possible that traces of hypo might be carried into the developer as a result of incomplete washing of the racks. With this in mind a small wooden frame was soaked in a fixing bath,

and without rinsing was dried for two days, and then soaked in a liter of developer in a small tank for three days. This developer was then tested and found to give some dichroic fog which has a different appearance from fog caused by sulphide. Moreover, no sulphide



could be detected by chemical tests. When hypo in increasing amounts was added directly to a fresh developer, the general result was to decrease the density of the image without producing any increase in fog. Dichroic fog was formed in only a few cases. From these tests it seems improbable that traces of hypo in a developer can form sulphide by chemical decomposition.

2. *Rubber.* Rubber bands are used to fasten the ends of strips of film to the racks for tank development, and in the tube machine mentioned a soft rubber washer and hard rubber base were in contact with the developer. Therefore, a handful of new rubber bands were placed in a 250 cc. bottle of developer and allowed to stand 24 hours at a temperature of 120° F. Another sample of developer was heated to boiling with rubber bands. In both these tests no excessive fog was produced and sulphide could not be detected. When rubber was heated with 10% sodium hydroxide alone, sodium sulphide was formed, but when heated with sodium hydroxide and sodium sulphite hypo was formed instead of sulphide. The same result was obtained with developer which contained sulphite.

3. *Free Sulphur.* Flowers of sulphur were added to a developer and tested, as with the rubber bands, by boiling and by keeping for 24 hours at 120°F. Solutions were then filtered and tested chemically

and photographically but no sulphide could be detected. However, so much hypo was formed that, after a strip of film had been developed in the solution kept for 24 hours at 120°F., a silver mirror was slowly formed on the walls of the glass tube containing the developer. This was due to reduction of the silver dissolved from the emulsion. The solution also had a muddy appearance from the precipitated silver. Similar tests were carried out with milk of sulphur made by acidifying a hypo solution. In all these tests the results were the same; no sulphide was formed in a developer by adding hypo, rubber which contains sulphur, or free sulphur. On the other hand, when free sulphur was added to a developer, either hypo or some other poly-thio salt which dissolves silver bromide, was formed.

4. *Decomposition of Gelatine.* When film is passed through a developer a small amount of gelatine dissolves in the solution. Ordinary gelatine may contain cystine as one of its constituant amino acids and cystine contains sulphur in organic combination. Moreover, cystine is quite soluble in alkalies. It was thought therefore, that if the gelatine in the emulsions contained traces of cystine this might get into the developer and be decomposed with the formation of sulphides. In order to test this possibility some pure cystine was added to a developer, both alone and with ordinary gelatine, and the solutions kept for several days at 120°F. The same test was also made at 90°F. No sulphide was detected in any of these solutions. It is known that the bacterial fermentation of protein bodies containing sulphur produces hydrogen sulphide and in these tests it is probable that conditions favorable to bacterial development were not present, although the solutions were inoculated from the fogging developer. Moreover, it seems improbable that sufficient cystine could get into a developer from photographic gelatine to account for the formation of sulphide in the concentrations found to exist. In considering the activities of bacteria and other organisms, however, a much more probable source of the sulphide was found.

V. The Reduction of Sodium Thiosulphate, Sulphite, and Sulphate by Bacteria, Moulds and Yeasts

1. *Literature.* The literature contains references to the reduction of thiosulphates, sulphites, and sulphates by many different organisms. Neuberg and Welde[3] found that with a mixture of sodium thiosulphate, sugar and yeast, hydrogen sulphide and sodium sulphite were formed, and in three days 15% of the theoretical yield of hydrogen sulphide was obtained. Tanner[4] studied the action of

[3] "Transformation of Thiosulphate into Hydrogen Sulphide and Sulphite by Yeast," by Neuberg and Welde, Biochem. Z. *67*, 111, (1914).

[4] "Formation of Hydrogen Sulphide from Certain Sulphur Compounds by Yeast-like Fungi," by F.W. Tanner, J. Am. Chem. Soc. *40*, 663, (1918).

30 different fungi and found that most of the strains liberated hydrogen sulphide from sodium thiosulphate. Ten were found to reduce sodium sulphate to hydrogen sulphide and a few reduced sodium sulphite. W. J. Wilson[5] found that in media containing sodium sulphite, glucose and iron salts, reduction of sulphite to sulphide is effected by B. typhosus, B. enteritidis, B. paratyphosus B, and other members of the Salmonella group. These examples are sufficient to indicate the great variety of organisms which are capable of reducing sulphites, or even sulphates to hydrogen sulphide. It is also of interest to note that a rapid deterioration of standard solutions of thiosulphate has been traced to bacterial action.[6]

2. *Experimental Investigation.* In order to confirm the theory that reducing organisms were responsible for the formation of hydrogen sulphide in the fogging developer, it was necessary to reproduce the effect in other samples of developer. For most tests the solution to be tested was placed in a 250 cc. bottle, the desired culture material added, and the sample kept in an oven at 90-95°F. The bottles were not quite full and were corked. In some cases the solution itself was tested, but generally a lead acetate paper was suspended in the top of the bottle and left for an hour or two, if necessary, to see if it would blacken. At first some of the tests gave negative results, but this was probably due to the fact that the bottles were opened too frequently for examination and, as will be should later, the absence of oxygen is a contributing factor in the formation of sulphide.

(a) *Experiments with Yeast.* In the experiments with yeast about 1 cc. of ordinary baker's fresh yeast was placed in a 250 cc. bottle of the solution to be tested. When yeast was added to a 1% solution of sodium thiosulphate a considerable yield of sulphide was obtained in less than 24 hours. With a 1% solution of sodium sulphite, sulphide was detected after four or five days. When MQ tank developer was diluted 1 to 3, and 0.25% hypo added with yeast, sulphide was invariably produced in 3 to 5 days. Finally, when yeast alone was added to a slightly used tank developer, and the bottle kept closed for a week, sulphide was detected in considerable concentration. Thus there is no doubt whatever that ordinary baker's yeast contains organisms which are capable of living in a developer and producing sulphide from the developer constituents.

(b) *Experiments with Slime.* The wooden wash tanks in which the motion picture film is washed after fixing become coated with a thin layer of slime if they are not cleaned frequently. Some of the slime was scraped off and kept in a bottle from which portions were taken and added to other solutions. The bottle containing slime was

[5] "Reduction of Sulphites by Certain Bacteria in Media Containing a Fermentable Carbohydrate and Metallic Salts," by W. J. Wilson, J. Hyg. *21*, 392, (1923).

[6] "The Stability of Sodium Thiosulphate Solutions," by Kilpatrick and Kilpatrick, J. Am. Chem. Soc. *45*, 2132, (1923).

partly filled with water from the tap and after keeping a few days a lead acetate paper blackened instantly when introduced into the top of the bottle. In this case the sulphide must have been produced from traces of sulphate in the tap water, or hypo from the water in the wash tank from which the slime was scraped. Sulphide was formed very slowly and in small amounts when slime was added to hypo solutions or to dilute developers containing hypo. However, when some of the slime was added to a slightly used developer and the bottle kept tightly closed for two weeks, a large amount of sulphide was formed. Therefore, the slime which collected on the walls of the wash tanks was capable of producing sulphide in a developer.

(c) *Bacteriological Examination of the Developer.* A sample of the fogging developer from the tank after standing for some time was examined microscopically[7] and found to contain numerous organisms, some of which were undoubtedly dead. The turbidity of the contaminated samples appeared to be caused largely by the suspended organisms.

A second sample obtained from the tank just as the first trace of fog became evident showed much the same bacterial flora as the first. This consisted chiefly of bacteria, bacilli predominating, although cocci were also present. Numerous filaments of an unidentified fungus were also present. Under anaerobic conditions in a medium of diluted developer to which peptone and lead acetate had been added hydrogen sulphide was produced on at least three occasions. It is not certain yet which one of the mixtures of microorganisms yielded the hydrogen sulphide nor can the peptone be ruled out as the source of it.

In view of all the experimental evidence produced, it seems certain that the sulphide in the fogging developers tested was formed from sulphite as a result of reduction by living organisms which grew in the developer. The organisms were probably introduced with the water, but may have come from the air. A deep tank favors such growth because oxygen cannot penetrate to the bottom of the solution where anaerobic conditions would exist. Possibly gelatine dissolved from the film acts as food for the organisms.

VI. Prevention of Fog

1. *The Precipitation of Sodium Sulphide from Developers.*

(a) *Precipitation by Silver Dissolved from Emulsions.* When a developer is used continuously no trouble is liable to occur from sulphide fog, because the silver dissolved from the emulsion precipitates the sulphide as fast as it is formed. This accounts for the sludge of silver sulphide sometimes found in such a developer.

[7] The authors are indebted to Dr. R. R. Mellon and Dr. W. S. Hastings of the Pathological Laboratory, Highland Hospital, Rochester, N. Y. for the bacteriological examination.

However, when sulphide is being formed continually, and the developer is not used for a day or two, all the silver is precipitated and the excess sulphide fogs the next film which is developed. This is why the fogging tendency appears so suddenly in such a developer. Further, it was found that by developing some film in the fogging developer, the excess sulphide was removed and the fogging tendency disappeared.

In this connection it is of interest to know the solvent power of a developer for the silver halides in the emulsions. The solubility of silver bromide in solutions of sodium sulphite was determined by Mees and Piper,[8] but when a film emulsion is passed through a developer other factors are present. Also, the silver halide first dissolved is reduced by the developing agent to free silver, either in a colloidal or a precipitated form. In the colloidal form it is partly responsible for the color of used developer solutions, and as a precipitate it forms a part of the black sludge sometimes found in the bottom of a tank of old developer. For example, the sludge which settled out of a tank of old No. 16 motion picture positive developer was found to contain 13.6% silver. In order, therefore, to determine approximately the solvent power of a developer for the silver halides in emulsions, the following procedure was followed:

A solution was made up containing sodium sulphite, sodium carbonate and potassium bromide in the same concentration as in a developer but no reducing agent was added. 500 cc. of the solution was placed in a tray and 12 sheets of film, 8″×10″, were put through the solution. Six sheets were developed at a time shifting the sheets from the bottom to the top of the pile constantly for ten minutes. The solution was then allowed to stand over night so that the turbid matter settled out and the clear liquid was pipetted off for analysis.

In order to determine the concentration of silver in the solution, sodium sulphide was added and the turbidity caused by the silver sulphide was compared in a colorimeter with the turbidity produced under similar conditions by a solution of known silver content. The solution of known content was prepared from the same stock solution of sulphite, carbonate, and bromide by agitating a sheet of clear photographic gelatine for ten minutes, and allowing that solution also to settle over night. This procedure was necessary in order that the gelatine content might be similar to that of the solution to be tested, for the protective colloid effect of the gelatine had considerable influence on the state of division of the precipitated silver sulphide. For the comparison 10 cc. of each solution was used. A measured amount of one-hundredth normal silver nitrate was added to the solution containing only gelatine, and the same amount of water to the solution to be analyzed. 1 cc. of 1% sodium sulphide was added to each and the comparison made. By a few trials the amount of silver nitrate required to give the same turbidity in each case

[8] "Sulphite Fog and Solubility of Silver Bromide in Sulphite Solutions," by Mees and Piper, Phot. Journ. *36*, 221 (1912).

was found. The results calculated in terms of silver bromide are given in Table 1. These figures, while not extremely accurate, are sufficient to show that the developing solutions are capable of dissolving a measurable amount of silver from the emulsions during development.

Table I

Solvent Power of Developing Solutions for Silver Halides

Developer[10] *Formula*	Composition[9] of Solution in grams per liter Na_2CO_3	Na_2SO_3	KBr	Emulsion	Equivalent of Silver Bromide per liter
MQ tank	12.5	18.75	0.75	Eastman Motion Picture Negative Film	0.17 grams
MQ tank	12.5	18.75	0.75	Eastman Motion Picture Positive Film	0.19 grams
MQ tank	12.5	18.75	0.75	Eastman Brilliant Velvet Bromide Paper	0.21 grams
MQ tank	12.5	18.75	0.75	Azo E No. 1 Developing Paper	0.60 grams
MQ_{25}	25	75	1.5	Eastman Motion Picture Negative Film	0.15 grams
MQ_{25}	25	75	1.5	Eastman Motion Picture Positive Film	0.15 grams
16X	100 (K_2CO_3)	100	3.75	Eastman Motion Picture Negative Film	0.56 grams

The effect of soluble bromide in diminishing the solubility of silver bromide is shown by the smaller value obtained with MQ_{25}, which contains much more sulphite than MQ tank, but more potassium bromide.

(b) *Precipitation by Lead Acetate or Silver Nitrate.* When a small amount of lead acetate was added to the fogging developer containing sulphide, it was precipitated out so completely that the developer again gave entirely satisfactory results. The precipitated lead sulphide settled out quite rapidly but even while in suspension it caused no trouble in development. With a developer which contained 0.01% sodium sulphide, it was found that when 0.04% of lead acetate was added and mixed thoroughly with the developer, all the sulphide was removed. Any excess of lead salt forms a precipitate which is probably a basic lead carbonate with possibly some sulphate or sulphite.

When silver nitrate was added in order to precipitate sulphide from a developer, the results were not very satisfactory. The reduction of the silver interferes with the rapid precipitation of silver sulphide, and the precipitate settles much more slowly than that of lead sulphide. Moreover, the developers to which silver nitrate had been added showed a tendency to produce a spotted dichroic fog

[9] Reducing agents were omitted from the solutions.

[10] "The Development of Motion Picture Film by the Reel and Tank System," by J. I. Crabtree, Trans. Soc. M. P. Eng., No. 16, 163, (1923).

which looked as though it had been picked up from the surface of the solution. It appears, therefore, that the most satisfactory way of removing sulphide from a developer is to stir in thoroughly a small quantity of a solution of lead acetate which precipitates lead sulphide.

2. *Attempts to Prevent the Growth of Yeast.* A series of solutions containing 1% thiosulphate and yeast were tested with various preservatives to see if the growth could be prevented. The substances added were phenol, 0.1% and 5%; thymol, sodium salicylate, 0.5% and 5%; formalin, 0.1% and 0.5%. Sulphide was formed in all these tests except with formalin.

When MQ tank developer was diluted 1 to 3 and 0.25% thiosulphate added together with yeast, sulphide was always formed. With this solution it was found that the addition of sodium salicylate in a concentration of 0.1% and 0.5% accelerated the formation of sulphide, while formalin in concentrations of 0.1% and 0.2% only acted as a retarding agent. Probably the sulphite in the developer combines with the formalin rendering it ineffective. In these tests, therefore, no substance was found which would prevent the growth of yeast in a developer. If the formation of sulphide is caused by some other type of organism perhaps it could be prevented more easily. At this time, however, the authors are unable to recommend any substance which can be added to a developer to prevent such growth. In case a tank of developer becomes affected, it should be thoroughly cleaned before a new batch is added in order to prevent infection from the tank.

Summary

1. Several samples of tank developer which suddenly began to give excessive fog were found to contain sodium sulphide.

2. The concentration of sodium sulphide in two of the fogging developers was determined photographically and found to be approximately 0.005% and 0.02% respectively.

3. When free sulphur was added to a developer, sodium thiosulphate or other poly-thio salts were formed but no sulphite could be detected. The formation of sulphide from thiosulphate or rubber in a developer is, therefore, improbable.

4. Many different organisms are capable of reducing hypo, sodium sulphite, and sodium sulphate to sodium sulphide. Certain unidentified fungi and several species of bacteria, some of them chromogenic, were found living in the fogging developer.

5. The formation of sulphide in developers was reproduced experimentally in the laboratory by adding yeast or slime. The evidence therefore indicates that the sulphide in the fogging developers investigated was formed by reduction of the sulphide by living organisms.

6. When a developer is used continuously, the dissolved silver precipitates the sulphide as fast as it is formed and no fog is produced.

In this connection, the solvent power of the developing solutions for the silver halides in various emulsions was measured.

7. A developer which gives sulphide fog can be revived by the addition of a small quantity of lead acetate which precipitates the sulphide as lead sulphide, or by developing a quantity of waste film therein.

8. No substance has yet been found which can be recommended as a preservative against bacterial growth in a developer.

DISCUSSION ON DR. DUNDON'S AND MR. CRABTREE'S PAPER

Mr. Renwick: I should like to say I enjoyed hearing this paper very much; it seems to be extremely valuable to the laboratories and there is only one suggestion I should like to make. I remember meeting with a sulphuretted hydrogen producing bacterium in the water supply of the firm for whom I was working in England. We looked up its history, and found that it frequently develops with enormous rapidity at certain seasons. I am not sure what the likelihood of yeast contaminating a bath is, but I am doubtful if it would be as great from this as from the extremely rapidly multiplying organisms I have mentioned, e.g., Beggiatoa.

Mr. Powrie: Have any data been obtained from developers made up with distilled and with ordinary water?

Dr. Dundon: My belief is that the organism present was probably not a yeast, but we tried the action of yeast first and believe it could get into the developer. That phase of the problem is being investigated further in the pathological laboratory of a local hospital and we hope to identify the exact organism eventually.

The developers which spoiled with use were made up with city water. Most of the samples of developer tested in the laboratory, as well as the hypo and sulphite solutions were made with distilled water. We have no data relating to the occurrence of the phenomena in practice with solutions made from distilled water.

THE HANDLING OF MOTION PICTURE FILM AT HIGH TEMPERATURES

By J. I. Crabtree*

SPECIAL care is necessary when handling motion picture film at high temperatures when high humidities usually prevail in order to insure that the sensitiveness of the film emulsion shall remain unimpaired before exposure and that the latent image shall be retained after exposure and before development. Special treatment is also necessary if development of the exposed film must be conducted at temperatures above 70°F. while adequate precautions must be taken during storage of the developed film in warm climates otherwise the keeping qualities of the film will be affected.

Effect of Temperature and Humidity on Motion Picture Emulsions

A. *Unexposed Emulsions.* Although definite data are not available on the effect of temperature on the speed of dry unexposed emulsions, experience has shown that if the temperature of a dry unexposed film is raised, for example, from 65°F to 100°F a considerable period of time must elapse before the speed and fog are affected to a sufficient extent to be of practical importance. Renwick[1] has investigated the effect of humidity at constant temperature on the speed of motion picture emulsions and states that at a temperature of 65°F the speed of a film emulsion in equilibrium with an atmosphere whose relative humidity varies between 0 and 80% may vary by 50% depending upon the particular emulsion.

Experience has shown that with unexposed negative film stored in an atmosphere at high relative humidity say 90% and at a high temperature, say 90° F. or 100° F., the speed of the emulsion rapidly falls off and the emulsion becomes fogged to an extent depending upon the period of storage.

B. *Exposed Emulsions.* In the case of exposed negative emulsions it is important that the latent image shall remain unimpaired and that the still unexposed portions of the emulsions shall not develop fog. At high temperatures and humidities certain chemical reactions occur in the film which destroy the latent image, and the image is said to "fade," that is, if the film is stored for any length of time the developed image is very much weaker or less dense than if the film was developed immediately after exposure. Apart from this fading of the latent image, under the above conditions of storage, the emulsion becomes fogged with time which destroys the quality of the developed image. High temperature, however, has a surprising-

* Communication No. 219 from the Research Laboratory of the Eastman Kodak Co.

[1] F. F. Renwick, Trans. Soc. M. P. Eng. No. 18 p. 69.

ly small effect on the latent image if the exposed film emulsion is dry, that is, if it is in equilibrium with an atmosphere of low relative humidity. The experience of numerous explorers in tropical countries who thoroughly dried out their film after exposure and before packing but who did not develop the film for several months afterwards thoroughly establishes this fact.

Effect of a Sudden Change of Temperature on Moist Film

If moist film, that is, film which is in equilibrium with an atmosphere of high relative humidity is suddenly cooled, moisture is apt to condense as droplets on the film emulsion which will cause spots on the developed film. Such spots are termed "moisture spots."[2] There is very little danger of the formation of moisture spots due to sudden cooling of the original unopened film cans. The most frequent cause of moisture spots is sudden cooling of the film when in a moist condition in the camera and retorts.

The Care of Motion Picture Film Before Exposure

From the above discussion it is seen that film must be kept dry and as cool as possible before exposure. The film however, must not be too dry, otherwise static may be produced in the camera with negative film, and in the printers with positive film. On leaving the factory, motion picture film as contained in the cans is in equilibrium with an atmosphere having a relative humidity of 70 to 75% but the paper wrapping absorbs moisture so that film which is a few months old is relatively dry. The film cans, however, are not perfectly water-tight and in a very moist atmosphere the packed film would absorb moisture very slowly so that it is preferable to pack film which is liable to be exposed to damp atmospheres in hermetically sealed cans. Film packed in this way can be secured on special order from the manufacturers. Five small cans are contained in an outer can with a soldered inside cover and after exposure the film can be repacked in this outer can and again sealed by soldering the outer cover. If the film is liable to be roughly handled it is preferable to construct carrying cases of heavy sheet metal or fibre impregnated with bakelite and fitted with gasketed covers which can be clamped down with suitable screws or clamps. The containers should not be unduly exposed to the sun, and a layer of white felt around the carrying cases serves to insulate the film from sudden heat changes. Positive film in the laboratory should be stored in the original cans at a temperature as near 65°F. as possible.

Negative films should not be retained for too long a period either in the retorts or in the camera because in a damp atmosphere moisture spots are apt to be produced as explained above. Film should be removed from the original container only as required and in the

[2] "Markings on M. P. Film Produced by Drops of Water" by J. I. Crabtree and G. E. Matthews, Trans. Soc. M. P. Eng. Vol. 17, *29*.

field a changing bag will eliminate the necessity of carrying an excessive number of charged retorts. If at the end of the day any unexposed film still remains in the camera this together with the exposed film should be packed away in cans so that it will not absorb moisture.

The Care of Motion Picture Film After Exposure and Before Development

If any considerable period of time must elapse after the negative film is exposed and before it is developed, the film should be dried out as thoroughly as possible in order to retard the fading of the latent image, and fogging of the emulsion, and to prevent the possible formation of moisture spots as explained above. The film should not be dried to the point where it becomes excessively brittle, otherwise it would be apt to crack or develop static when unrolling previous to development. Two methods of drying the film are possible as follows:

A. Thoroughly dry out a quantity of clean paper by heating in an oven and pack loosely in a box fitted with a tight lid. Place the loosely wound film in the center of the dry paper and allow to remain over night. The desiccated paper rapidly absorbs moisture from the film and should be redried daily. On removing from the drying box, repack the film immediately.

B. A more rapid method of drying the film consists in placing the film in a container together with calcium chloride which rapidly extracts moisture from the surrounding air. Calcium chloride is supplied commercially either as sticks or as porous lumps which pulverize when shaken so that if the chloride were placed in close contact with the film, fine particles of dust might be shaken onto the film, while in time the calcium chloride liquifies and this might also run on to the film. It is better, therefore, to use pumice or asbestos wool impregnated with the calcium chloride so as to prevent possible injury to the film by the pulverized or liquid chemical. Thoroughly soak the broken pumice or asbestos wool in a saturated solution of the calcium chloride and then dry out thoroughly on a shovel or a piece of sheet iron over a fire; place the pumice on the bottom of a wooden box or metal can and support the film over this on a suitable perforated shelf. A convenient drying box is made by soldering together two motion picture film cans back to back and then perforating the base now common to the two cans. The absorbent material may then be placed in one section of the twin can and covered with a little absorbent cotton and the film placed in the adjoining section. When the pumice or asbestos wool loses its desiccating property by becoming moist it may be restored by reheating over the fire, and this process may be repeated indefinitely.

The Development of Negative and Positive Motion Picture Film at High Temperatures

Although in the larger motion picture laboratories it is possible to control the temperature of all developing solutions, many small

laboratories have no equipment for cooling so that it is necessary to work with solutions at existing temperatures and wash water as high as 90° F. It is, therefore, necessary to so harden the film that it will withstand washing at this temperature and not become unduly softened.

Motion picture negative and positive emulsions as they leave the factory melt in water at a temperature around 95° F. At temperatures above 75° F. the emulsion swells and softens to such an extent that it cannot be safely handled on drying reels without danger of scratching although old film will withstand higher temperatures than films fresh from the factory, because the gelatine emulsion hardens with age. It is necessary, therefore, that film should not be in a swollen condition as it leaves the wash water while it should be sufficiently hardened so that it does not melt during drying. Prevention of swelling of the gelatine is the most important point to observe in high temperature processing. The slow drying of film in hot moist climates is usually a result not only of high humidity, but of the excessive quantity of water in the swollen film which has to be evaporated. The swelling of gelatine may be prevented or retarded by the following methods:

A. By the use of concentrated solutions. For example, in a 10% solution of sodium sulphate a gelatine emulsion which normally melts at 95° F. melts at 110° F. and the rate of swelling at any given temperature is retarded in due proportion. Prolonged development of negative film for say 10 to 15 minutes in a dilute developer is fatal at temperatures above 80° F. The concentration of the developer should, therefore, be so adjusted that no appreciable swelling occurs.

B. By the addition of inactive salts to the solutions. Instead of increasing the concentration of the developer, salts such as sodium sulphate, sodium phosphate, and substances such as glucose and sugar may be added which both prevent swelling of the gelatine and retard development. Since in many cases 4 or 5 minutes is the most convenient time for development, if a developer otherwise requires three minutes at a given temperature, enough sodium sulphate may be added to retard the development time to 5 minutes. If, on the other hand, it is desirable to shorten the time of development when the neutral salt has been added, the concentration of the developer ingredients should be increased.

C. By permanently hardening the gelatine. When the swelling of gelatine is retarded by the use of a concentrated solution the gelatine is said to be temporarily hardened. If in this unswollen condition it is chemically tanned or hardened by such agents as formaldehyde, chrome alum, or potassium alum, it is said to be permanently hardened and will swell again only very slowly on immersing in hot water. It is obvious that the gelatine should be permanently hardened as early as possible during the development process. It has been proposed to harden the film with formalin both

before and during development and Messrs. Ilford Ltd.[3] have patented a mixture of formalin and a salt such as sodium sulphate for hardening the emulsion previous to development. However, it is necessary to wash thoroughly after bathing in the hardener and previous to development. The addition of formalin directly to the developer has also been recommended and gives satisfaction in certain cases but in many instances it causes fog, while for maximum hardening the quantity of formalin must be carefully adjusted to the quantity of alkali and sulphite in the developer. The hardening effect of formalin in developers is now under investigation in this Laboratory.

At the outset, the use of formalin was definitely abandoned for deep tank work owing to its objectionable odor and injurious effect on the nasal membrane of the operatives. Of the remaining hardening agents, namely aluminum and chrome alums, chrome alum produces the greatest degree of tanning although a solution of chrome alum is comparatively sensitive insofar as a slight change in the acidity may largely effect the hardening properties, while the hardening properties of the solution fall off or decay with time when the solution is contaminated with developer.

The most suitable stage at which to harden the film with chrome alum is immediately after developing and before fixing. If a preliminary bath is given before development the alum must be thoroughly washed out, otherwise a precipitate of chromium hydroxide will form on the film in the developer. Likewise, alums are precipitated on adding to a developer.

A chrome alum fixing bath is not entirely satisfactory because even without use the hardening properties fall off and are destroyed in three or four days at high temperatures, and with use by virtue of the transfer of developer, the rate of falling off of the hardening properties is still more rapid. A chrome alum fixing bath is satisfactory, however, if used for not more than a day or two but it is, therefore, uneconomical for deep tank work.

Practical Instructions for Developing Negative and Positive Film at Temperatures from 75° to 85° F.

The Developer: Use any good developer which fully develops in from three to four minutes at 85° F. It is very important not to prolong development beyond this period so that the film does not become unduly swollen. If the developer requires a longer time of development, increase the concentration and reduce the time of development in due proportion. For example, if a developer normally requires eight minutes for negative film at 85° F. make it twice as strong and it will then develop in approximately four minutes. If the developer tends to give excessive fog at this temperature add a little potassium bromide. If streaked fog is produced, which is caused

[3] British Patent No. 128,337. U. S. Pat. No. 1,424,062.

by aerial oxidation of the developer during examination of the film add one part in 500,000 of Pinakryptol Green which will entirely eliminate aerial oxidation fog.

The following developer formula gives results very free from fog with a minimum of swelling. It is especially suitable for use with negative film.

	Metric	*Avoir.*
P-aminophenol (Kodelon)	7 grams	3 lbs.
Sodium sulphite (desiccated)	50 grams	21 lbs.
Sodium carbonate (desiccated)	50 grams	21 lbs.
Water to make	1 liter	50 gal.

The Hardening Bath. After development rinse the film for not more than two to three seconds in water and immerse for at least three minutes in the following hardening solution.

	Metric	*Avoir.*
Potassium chrome alum	30 grams	12 lbs.
Water to make	1 liter	50 gal.

Agitate the film for 30 to 45 seconds when first immersing in the hardener. This will tend to prevent any possible blisters, streakiness, or chrome alum stains. If the film is not rinsed slightly and agitated as above, the alkali in the developer is apt to precipitate a sludge of chromium hydroxide on the film, especially with a partially exhausted hardening bath, which is difficult to remove. Blisters may tend to form if the film is swollen on immersing in the hardening bath as a result of decomposition of the carbonate in the developer by the chrome alum which is normally acid, but agitation will tend to prevent the formation of such blisters.

The hardening properties of the above bath depend on

A. The acidity of the bath

B. The alkalinity of the film

C. The age of the bath and quantity of developer carried over to it by the film

D. The time of immersion of the film in the bath

A plain chrome alum solution is sufficiently acid to neutralize a considerable quantity of alkali carried over from the developer but the film should be rinsed in order to prevent the bath from rapidly becoming alkaline. The addition of acid to the bath is not recommended because this tends to produce blisters. It is necessary, however, that the film should contain a certain quantity of alkali on immersing in the hardening bath in order to secure maximum hardening. As developer is carried over the color of the bath changes slowly from violet-blue by artificial light when freshly mixed to a yellow-green, in which condition it ceases to harden and should be replaced with a fresh bath. A fresh bath will remain violet colored and retain its hardening properties indefinitely, but once a small quantity of developer is added certain chemical reactions occur which gradually destroy the hardening properties depending upon the

quantity of developer added. The hardening bath should never be overworked and a new bath should be prepared as soon as it ceases to harden satisfactorily.

The time of immersion in the hardening bath should never be less than three minutes which is usually sufficient to give maximum hardening.

The Fixing Bath: Any hardening or non-hardening fixing bath may be used, because on leaving the chrome alum bath the film should be so hardened that the gelatine will not dissolve off in boiling water. Either a 30% solution of hypo with the addition of 2.5% sodium bisulphite or the regular alum-acid fixing bath or chrome alum fixing bath may be used, though a hardening fixing bath is not necessary.

Washing: After thoroughly fixing the film for about five minutes, wash for ten to fifteen minutes. If running water is not available immerse in a tank for five minutes and in a second one for another five minutes. A third immersion in clean water will eliminate most of the hypo though if permanency is required the film should be thoroughly washed at a later date when an abundant supply of cold water is available. The temperature of the wash water for the above treatment should not exceed 85° F.

Film may be successfully washed in sea water providing it is finally given two or three soakings for five minutes in pure water. It is also desirable to rewash the film at a later date in pure water.

The Development of Negative Motion Picture Film at Temperatures up to 95° F.

If the temperature of the solutions and wash water exceeds 85° F. the following procedure must be followed:

Development: Any concentrated developer which gives good contrast in from two to three minutes at 90° F. may be used providing 10% of sodium sulphate crystals is added to the developer. This is in the proportion of one pound of sodium sulphate per gallon of developer. It is very important to develop rapidly or the emulsion will soften and swell excessively. After developing, rinse the film in water for one or two seconds only and transfer to the following hardening bath for three minutes.

Hardening Bath:

	Metric	*Avoir.*
Sodium sulphate (crystals)	120 grams	50 lbs.
Potassium chrome alum	30 grams	12 lbs.
Water to make	1 liter	50 gal.

Agitate the film from thirty to forty-five seconds when first immersed in the hardener in order to prevent blisters, development streaks and stains.

Fixing and Washing: Follow the instructions given above. The temperature of the wash water should not be over 100° F.

The Relative Temperatures of the Various Solutions

In high temperature work it is important that the temperature of the various solutions should be maintained as nearly constant as possible, that is, the temperature of all the solutions should be equal because if a swollen film is subjected to a sudden change of temperature, for example, if it is removed from a hot solution to a cold one and vice versa the gelatine film is subjected to strain and a leather-like graininess of more or less coarseness will appear all over the film which effect is known as reticulation. Recent experiments have shown that excessive graininess of film finished in hot weather is a mild form of reticulation. The effect of a sudden change of temperature is a maximum when the film is excessively swollen and a minimum when unswollen and hardened. Several procedures, therefore, are possible as follows:

A. Maintain the temperature of all solutions equal to that of the wash water.

B. Use a cool developer and warm hardener, fixing bath, and wash water.

C. Use a cool developer and hardener and warm fixing bath and wash water.

All the above give good results though C. is the best procedure if cooling is possible. The wash water may be either hot or cold, that is, once the film is tanned in the unswollen condition it will withstand sudden and severe changes of temperature without reticulating.

Drying of Film at High Temperatures

The usual difficulty encountered when drying film at high temperatures when high humidities usually prevail is a result of excessive swelling of the gelatine which, therefore, contains an excessive quantity of water. If swelling of the film is prevented by the above recommended procedure, drying will be rapid and can be hastened by raising the temperature of the drying air which in turn raises the relative humidity without danger of softening the film emulsion. Rapid changing of the air in contact with the film surface is also of importance.

In the field, a mosquito netting cabinet is necessary to prevent access of insects to the film.

Excessive graininess of the film which is often produced by slow drying at high temperatures of excessively swollen film, does not occur if swelling of the gelatine is prevented as explained above.

Effect of Hardening on the Wearing Qualities of Negative and Positive Film

Experiments have shown that the wearing qualities of film processed in the above manner are not materially affected as a result of the excessive hardening with chrome alum. If the gelatine coating,

however, is excessively swollen at any period and especially before hardening the structure of the finally dried hardened gelatine is more or less spongy and it has, therefore, much less strength than gelatine which has not been swollen.

Apparatus: Suitable apparatus for handling motion picture film in the field at high temperatures has been described in previous papers.[4]

The Care of Developed Motion Picture Film at High Temperatures

At normal temperatures film base undergoes only a very slight change with age—so slow that no alteration of its physical properties takes place for several years, providing the film is not allowed to become excessively dry. Under certain conditions, however, the film base undergoes actual chemical decomposition depending on the conditions of processing and storing.

It has been found that small traces of impurities in the gelatine film such as residual chemicals left in the film either as the result of imperfect fixing or the use of an exhausted fixing bath, or as a result of imperfect washing, or thorough washing in impure water, very materially hastens the decomposition. Film which is to be kept for any considerable length of time should, therefore, be thoroughly fixed in two successive fixing baths and thoroughly washed in pure water.

Experience has also shown that even film which has been thoroughly fixed and washed when stored at high temperatures rapidly becomes brittle, the film base undergoes chemical decomposition and in a few years time the film image is destroyed by the decomposition products. At normal temperatures the rate of decomposition is negligible but with rising temperature above 80° F. decomposition takes place at a very rapidly increasing rate. It is very important, therefore, that film should be stored at a temperature not higher than 60 to 70° F. though a temperature around 40 to 50° F. is to be preferred.

[4] "A Portable Apparatus for Developing M. P. Film at High Temperatures" by J. I. Crabtree. B. J. Phot. Aug. 1918, *379*.

"The Development of M. P. Film by the Reel and Tank Systems" by J. I. Crabtree, Trans. Soc. M. P. Eng. Vol. 16, *163*.

DISCUSSION ON MR. CRABTREE'S PAPER

VOICE: Is it possible to use a more concentrated solution of chrome alum? When working at temperatures above 70°, I left a film in a 10% solution of chrome alum for 1-1/2 minutes and placed in the hypo without rinsing. Is there anything wrong in this?

MR. CRABTREE: Our experiments show that if a curve is plotted showing the effect of concentration of a chrome alum solution on the hardening produced, maximum hardening is obtained with a 2% or 3% solution. Above this concentration, chrome alum stains are liable to be produced; that is, the film will be stained green while a scum of chromium hydroxide is apt to form on the surface of the film on first immersing in the chrome alum solution, and unless this is mopped off, it leaves a greenish deposit on the film after drying which cannot be removed. The expense of making 50 gallons of a 10% solution should also be considered.

REDUCING THE APPEARANCE OF GRAININESS OF THE MOTION PICTURE SCREEN IMAGE

By J. H. Powrie*

TWO years ago at the Spring Convention a paper was presented by A. C. Hardy and L. A. Jones on the graininess of photographic materials used in the Motion Picture Industry.

This Society appointed a Committee on films and emulsions, one of the matters under consideration being the question of reducing the appearance of graininess in the projected image.

While I was on this Committee I had nothing to contribute that was in any way helpful to the Industry. I have, however, been engaged on a problem in the Warner Research Laboratory in which the graininess of the negative image is a factor of serious moment, and our method of attack and results obtained are of interest to this Society.

I do not wish to encumber the business of this convention with the details of the research work in this connection, for the subject of graininess has been very ably investigated by Dr. Mees and the results of his work appear in a paper printed in the Journal of the Franklin Institute of May 1921. There is also the paper by Hardy and Jones, above referred to, which is printed in Number 14 of the Transactions of this Society.

With the ever increasing refinements that have taken place since the motion picture came into existence, the silver bromide emulsion which is the sensitive medium for the production of the image, has received less consideration by the producer and the exhibitor of the pictures or the mechanical engineer who has to do with the design and construction of the apparatus for taking and projecting them, the pictorial value of the picture being subordinated to the machinery for taking the pictures and the means of presenting it before the public. The sensitive film as it comes from the manufacturer is generally accepted as perfect a product as can be produced economically with our present knowledge of photographic chemistry and film manufacture.

We have been obliged to sacrifice somewhat of the finer texture of the old wet plate process that made such beautiful lantern slides for the increased sensitiveness of the gelatino-bromide emulsion on the film with an attendant increased graininess which is not objectionable until the negative image is made so small that it must undergo a magnification of several diameters. Through this enlargement the question of graininess obtrudes itself into the picture. A few years ago the graininess of the picture was not so important. The standard of

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the motion picture in pictorial art was far inferior to the still picture or the lantern slide, and no pretensions were made that it had any merit beyond the story and the motion. Today the motion picture is no longer a makeshift and in order to obtain the pictorial quality of the stereopticon or lantern slide in our pictures, something should be done to bring about a marked improvement in the quality of our photographic results.

I think that it would be very helpful to a proper understanding of the possibility of minimizing graininess to read the summary of the work of Hardy and Jones from the transactions of this Society.

1. "Minimum graininess is obtained by minimum exposure, the graininess increasing continuously with increasing exposure.

2. The time of development of the negative has practically no effect on the graininess of the resulting print when the development of the print is adjusted to compensate for the differences in the contrast of the negatives.

3. The use of diluted developing solutions to develop the negative produces a slight increase in the graininess of the print. This effect can usually be ignored in practice.

4. The graininess of the print was found to be almost independent of the developing agent used to develop the negative. Practically all of the common materials such as pyro, metol-hydroquinone in various combinations, amidol, etc., were tried and only negligibly small differences found between them.

5. Contrary to the claims that are often made, the fixing, washing and drying conditions were found to have no effect on graininess. The photographic materials were subjected to very severe conditions of warm solutions and slow drying in warm moist air but no increase in graininess could be measured.

6. The effect of the light used in printing on the graininess of the print was investigated. Printing by ultra-violet light was found to decrease the graininess. The graininess was found to be less when a diffuse beam of light was used in place of the usual parallel or specular beam. Practical considerations, however, make it undesirable to attempt to decrease graininess by this means.

7. The graininess of the print was found to be practically independent of the concentration or the nature of the developing agent.

8. An explanation is offered for the excessive graininess which sometimes occurs with certain types of subjects. This is probably due to the nature of the subject which requires rendering large unbroken areas by positive densities which lie near the maximum graininess. The various remedies for this condition are discussed."

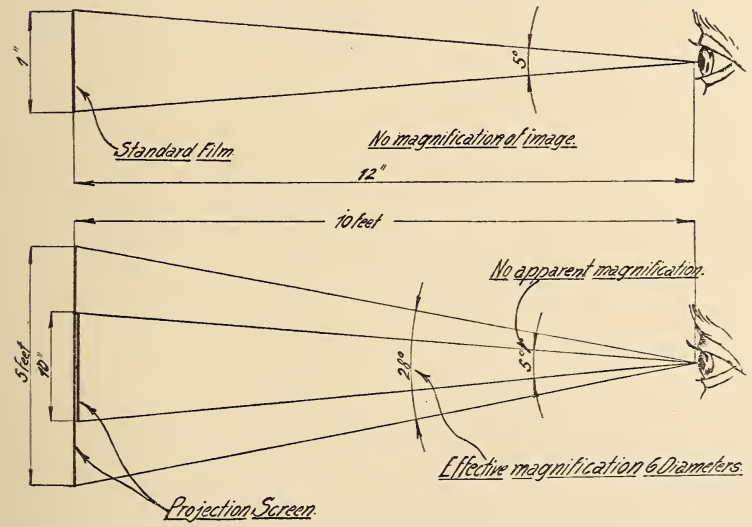
It is very evident that the more the image is magnified the more apparent the graininess and conversely, the less the magnification the less the grain.

I remember back in the infancy of the industry that the film

image was quite large. We had the use of an old Mutoscope camera a few years ago that worked with the beater movement that carried a film 2-1/4″ wide. Films of this size while very satisfactory on projection so far as reducing the appearance of grain, are entirely impractical of application in our present theatre equipment already installed for projecting the standard film. It is a simple matter however to print the positives optically and reduce them to the present standard.

I believe the Widescope camera people obtain their results in this way, and in talking with Mr. A. F. Victor a few years ago, he suggested the plan of running the standard negative stock through the camera horizontally, moving the image seven perforations instead of

Fig. 1.



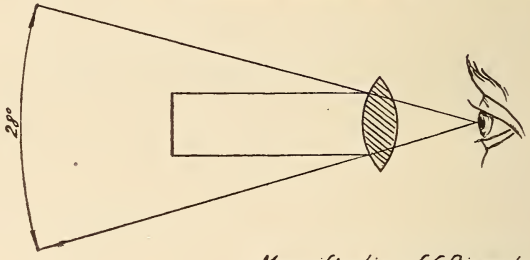
four and using an optical printer copying the positives at right angles to the negative. This maintains the rectangular form of the image in the horizontal position, the increased area of the negative to the standard positive copied from it being as 16 to 9. Mr. W. W. Hodkinson I believe also tried some such scheme as this with the object of getting a wider angle to the picture. Apparently however no one has given serious thought to trying to improve the pictorial value of the motion picture by increasing the size of the negative image and making the positives by reduction. In our consideration of this method of working we should not lose sight of the fact that if we are going to increase the size of the negative image with view to getting rid of the grain that the increase in negative area should be sufficient

to fulfill the conditions. We have analyzed the magnification of the projected image with relation to the observer in the following manner: (Fig. 1.)

Viewing a strip of standard film at a distance of 12 inches, or reading distance we have adopted this ratio of one inch (the diameter of the film image) to one foot (the viewing distance) as a unit of one, their being no magnification of the image. If we increased the diameter of the film image by projection to ten inches and viewed it at ten feet we have maintained the same ratio and there is still no effective magnification apparent. But if we will magnify by projection the one inch image on the film to five feet or 60 inches on the screen

Fig. 2.

Six times enlargement with lens gives effective magnification as seen on the projection screen.



Magnification of 6 Diameter.

and still view it at the same distance, we have obtained an effective magnification of six diameters. We find that the graininess of the film image can be examined quite as satisfactorily on the film itself by examining the image with a magnifying glass that gives a relative magnification to the film of six diameters, as though we viewed the projected image five feet in diameter at a distance of ten feet. The majority of spectators in a theatre are not as close as this to the screen. The same angle of vision 28° would give us six diameters for a twenty foot picture viewed 40 feet from the screen. (Fig. 2)

In connection with the work undertaken in the Warner Research Laboratory a camera is in use which carries a strip of negative film 1-7/8 inches in width which is ½ an inch wider than the standard film. The film passes through the camera horizontally, the height of the image being nearly an inch and a half, and the film being moved 2 inches at each exposure giving us a picture four times the area of the positive. An optical printer with the negative and positive film running at right angles gives us by reduction the standard positive.

(Fig. 3) Some negatives were made Saturday by our Mr. Conklin and I would like to show you the results on the screen in comparison, as the same subject was photographed with the large film as well as the standard negative film. The positives from each being made on Eastman news stock, one being made by reduction and the other by contact. Some of these negatives were made by artificial light in the

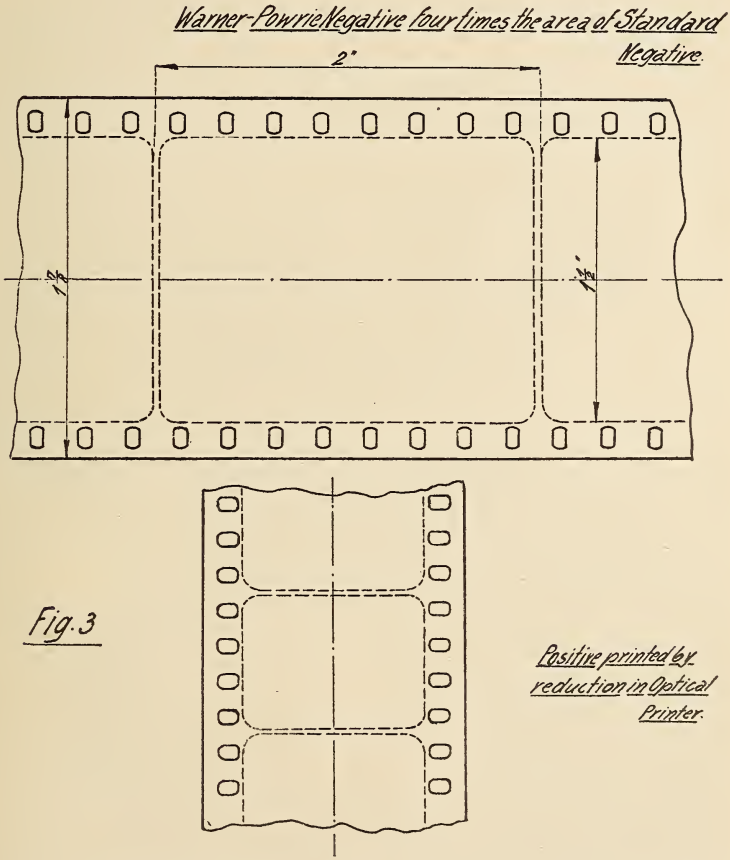
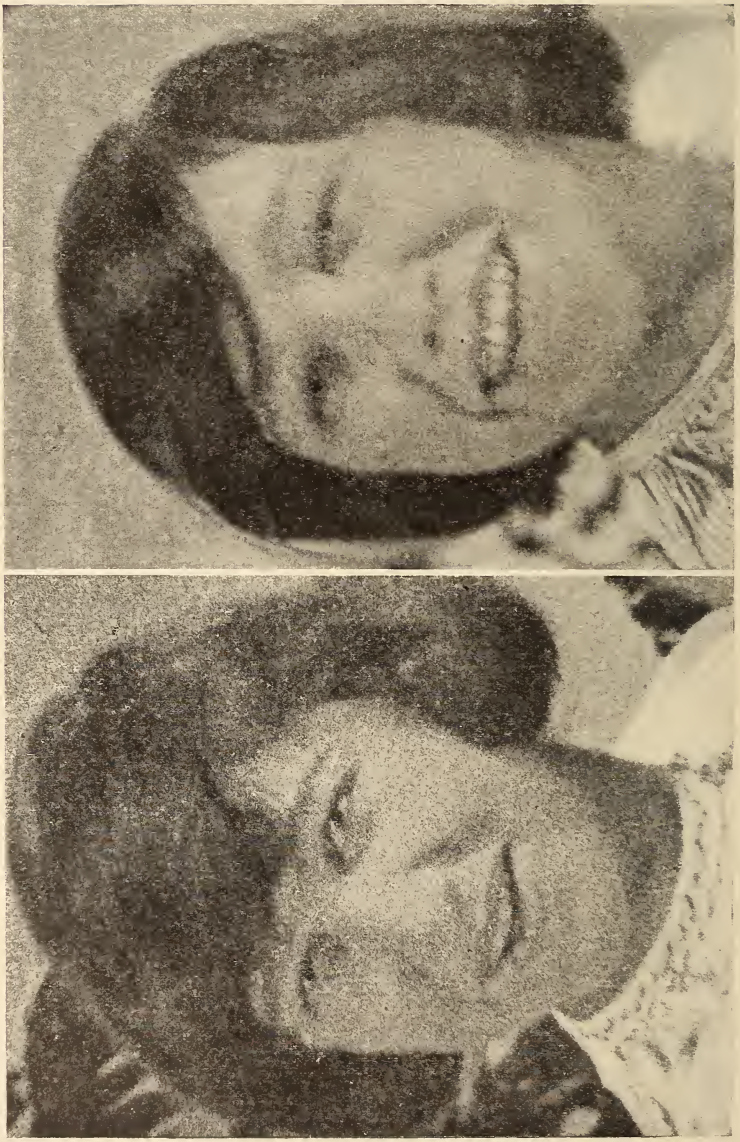


Fig. 3

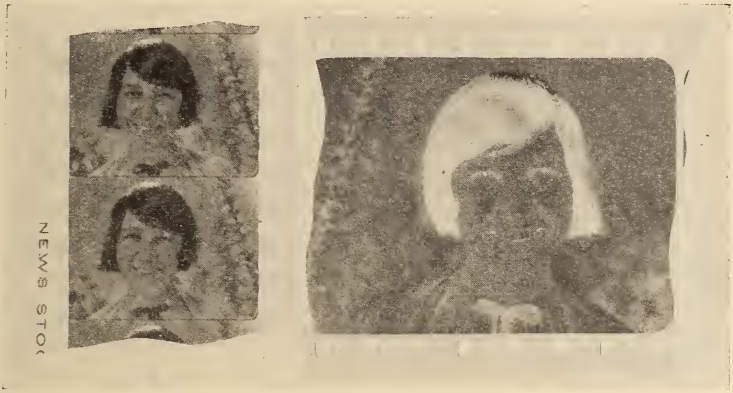
studio in which five 1000 Watt Mazda Lamps were used. A 100 millimeter B. & L. "Tessar" lens working at an aperture of F.3.5 was employed on the large film and a 50 millimeter "Tessar" of the same aperture for the standard film. I would like to show you the results on the screen. (See half tone reproductions enlarged 16 diameters to show graininess)

An examination of the two negatives will at once show the advantages that will be obtained in working with the larger negative.



Positive from standard negative enlarged 16 diameters. Positive from W-P negative enlarged 16 diameters.

In addition to getting better definition and eliminating the graininess the large negative offers the possible solution of making far more satisfactory duplicate negatives than can be obtained in any other way. We can also make better enlargements or "blow ups" as they



are called for lobby displays than can be made from the standard film. In my opinion if we will give this matter serious consideration I feel that the advantages will outweigh the increased cost in cameras and equipment for the production of better pictures.

DISCUSSION ON MR. POWRIE'S PAPER

MR. STARK: I should like to ask what type of illumination was employed in printing from the larger negative to the positive.

MR. POWRIE: It is copied through a lens with an ordinary thousand watt mazda lamp, and the light was diffused by opal glass back of the negative. There is no loss in definition caused by copying.

MR. RICHARDSON: The ordinary picture it seemed to me was worse than we ordinarily see; was this because I was too close to it?

MR. POWRIE: We did not try to make it bad. It was made in the regular way. Every effort has been made to get the grain to show as much as possible to make the two comparable.

MR. CRABTREE: What is the area of the negative with regard to that of the positive.

MR. POWRIE: We have increased the size of the negative image with this camera to 1-7/8 inches, this being the diameter of the film running horizontally (drawing). The image between the perforations is 1-1/2 inches, and the film is moved 2 inches, which gives us four times the area, so that when copied it gives a positive equal to a quarter of the original negative, in area.

MR. CRABTREE: Is there any difficulty in keeping the film flat in the gate?

MR. POWRIE: No, we have not experienced any difficulty.

MR. RICHARDSON: I am convinced the short viewing distance is not responsible and am of the opinion that the demonstration was not a fair one. One picture particularly was very good indeed while the other was worse than the ordinary picture seen on the screen. Had the viewing distance been responsible, both pictures would have appeared the same. What I am seeking to determine is the relative excellence of the photograph compared with a reduced photograph of ordinary excellence.

MR. POWRIE: I don't think that the negative made on the standard film was worse than the ordinary negative is. It was made with regular Eastman stock and under conditions obtained in the average studio by a man quite expert in that line, and every effort was made to make an impartial representation, but, remember, you are relatively close to the screen. You would never be so close in an ordinary theater.

MR. RICHARDSON: That is the point; at the same viewing distance why does one show up so much worse than the other?

PRESIDENT JONES: I think I can explain Mr. Richardson's uncertainty. The demonstration was to show there is less impression

of graininess in one than in the other. Reduction of four times the diameter does eliminate the grain, as we expect it to. The first photograph did not, in my opinion, show much more graininess than one would expect. As seen from your position, the picture is subtending an enormous visual angle as compared with that in the ordinary theater.

DISCUSSION ON REPORT OF STANDARDS AND NOMENCLATURE COMMITTEE

MR. PORTER: Last year a number of things were approved which have stood so far without change; of course, they are open to discussion here, but if they are changed, they must lie over another six months.

(Motion duly passed that the standards and nomenclature initially accepted at Roscoe be approved.)

I think we will make best progress if we take up the new items one at a time.

"Cutting width of 35 mm. positive film: The Committee discussed the standardizing of the cutting width of standard positive film. After very careful consideration, the Committee agreed in recommending that the standard maximum cutting width shall be 35 mm. (1.378") for the following reasons: (1) When discussing film widths in the metric system, this film is known as 35 mm. and we think it desirable that all film widths should be represented by whole numbers in the metric system as is already the case with the 28 and 16 mm. positive and 35 mm. negative films, all of which were approved for standardization at the last S.M.P.E. convention. (2) Being a maximum cutting width, its main purpose is to inform the manufacturer of apparatus as to the maximum width for which he must allow. (3) While the Committee is aware that film appreciably below 1.375" is commonly met with in practice, due to shrinkage and other causes, it seems desirable to establish a minimum width for freshly cut film of 1.375" in order to avoid the possibility that film much below this dimension should be regarded as conforming to our standards. (4) The Committee believes that the adoption of these dimensions will not involve the alteration of any existing apparatus."

(Motion duly passed that the recommendation be accepted.)

MR. PORTER: "Form of perforation: The question of standardizing the form of perforation for 35 mm. positive film was discussed and it was decided to hold this over until some future time as it is probable that several forms will be tried out during the coming year. Cutting width and form of perforation were the only two matters in question. All other dimensions, etc., of 35 mm. positive film remaining as already agreed upon and reported at the 1924 spring convention."

(Motion duly passed that the recommendation be accepted.)

MR. PORTER: "Projection speeds: It was decided on account of complications involved, that the Committee did not have sufficient data to make a definite recommendation. Arrangements were made with Mr. Griffin of the Nicholas Power Company to have a demonstration at Chicago."

Since this report was printed, tests of various projection speeds at a screen brilliancy of tenfoot candles with the shutter running and no film have been conducted by your committee assisted by Messrs. Earl Dennison, R. C. Peck, Roger Hill, and Herbert Griffin. We came to the unanimous and definite conclusion that a projection speed of 80 is best with a minimum of 75 and a maximum of 85. It is realized fully that there are numerous factors entering into this problem such as screen brilliancy, type of picture, type of shutter, etc., and that under certain conditions, other speeds may be permissible or necessary. However, all these considered, your committee recommends 80 feet per minute as the best practice. We will now demonstrate these various speeds to you, covering a range of from 60 to 95 feet a minute. (Projection of demonstration reel of film.)

Mr. Richardson: I have repeatedly protested against the sixty-feet-per-minute projection speed adopted by this Society several years ago. Such a speed is entirely impracticable in the many theaters where high screen brilliancy prevails, because it could not be applied without very bad flicker. On the other hand, any speed in excess of that necessary to eliminate flicker and set up naturalness of action is bad because of excessive strain and wear on the projector mechanism and the sprocket holes of the film.

Up to eighty feet a minute, projection is possible without any increase in the projector gate tension now used. At eighty feet per minute, flicker is totally eliminated, even where screen brilliancy is very high, and that speed gives as natural action as can be had with any speed. I am convinced that eighty feet of film per minute represents good projection practice under modern conditions and I trust this Society will adopt it as standard recommended practice.

Mr. Norrish: Do I understand that the Society recommends 80 instead of 60 for taking?

Mr. Porter: No, in that point we felt that the camera-man will take pictures at different speeds, and he will do this according to the work in hand, so that we have worked on the basis that the projection speed should remain constant and the cameraman change his speed to meet different conditions.

Mr. Abbott: Mr. Porter says that the cameramen take pictures at different speeds, and if various speeds are used, how are we to know which one should be used for such a test as this?

Mr. Porter: I think you will all realize this is a problem in which there is an endless number of variations and the best we can do is to cut corners and recommend what is generally good practice.

I call attention again to this clause in the report: "It is realized fully that there are numerous factors entering into this problem such as type of shutter, screen brilliancy, type of picture, etc., so that under certain conditions, other speeds may be permissible or necessary."

MR. RICHARDSON: With the brilliant screen illumination of today, flicker is far worse than it was and the first consideration is to eliminate it.

MR. DENNISON: Disregarding flicker, the action is too slow at 60.

(Motion duly passed that recommendation concerning projection speeds be accepted.)

MR. PORTER: The next question on our report was discussed at the last meeting and turned back to the Committee, that of aperture sizes for cameras and printers: "After thorough discussion of standard sizes for apertures for camera and printer, it was decided to place before the Society the same dimensions of apertures as recommended by the Standards Committee at the 1924 spring convention, with the additional notation that in order to secure the black border, the camera aperture corners may be either round or square, as desired, but the corners of the projector aperture must be square. The Committee will be prepared to repeat the demonstration given at the spring convention if the Society so desires." The various apertures are printed in the little bulletin sent out to you but we didn't have a chance to check the proof and some of the figures are misplaced, so that I will ask Mr. John Jones to take over the discussion on this.

MR. JOHN JONES: I have a letter here from Mr. Mitchell in connection with the size of apertures.

MITCHELL CAMERA COMPANY
6025 Santa Monica Boulevard
Los Angeles, Cal.

Sept. 25, 1924.

Mr. Loyd A. Jones,
Edgewater Beach Hotel,
Chicago, Ill.

RE: APERTURE SIZES

Dear Mr. Jones:

At the Boston meeting the Society approved of a standard aperture for Ph. Projectors of .6795x.906.

The camera aperture should be near the same size as the projector, for the reason that the Director and the Cameraman have no other means to compose their picture than through the camera aperture.

Each camera manufacturer has left a hole through which to make an exposure, some were better than others from a practical standpoint, some were terrible from any standpoint, and caused the Cinematographer and Producer needless trouble and expense. He had to be a good guesser to get any composition at all.

Many camera apertures ran way over into the perforations, and characters on the side lines would be entirely cut off when the scene was projected.

When the Cinematographer and Director compose their scene, it is necessary that they have within the margins of the aperture, that which is going to show on the screen, for a little of this or that cut off often destroys the balance of the whole scene, and they must not be left to guess how much is to be cut off by the projector.

We must therefore establish a camera aperture that will give the photographer a definite outline to work to.

One well known make camera aperture is .723×.973, but with your projector aperture of .906 wide, this is over 1/16″ to be cut off by the projector, entirely too much, and the Photographer must school himself in the use of this, or he will be cutting his characters in half on the side lines.

We use an aperture .723×.920, and this size serves admirably, since there is only a margin of .007 on each side to be cut off.

The height could be increased to have the same margin at top and bottom, with no detrimental effect, if this were believed advisable by the Society.

The Printer aperture can be any size larger than the camera aperture, up to the full 1″×.748. Most laboratories out here use the continuous printer, so only the one dimension enters into the result.

If it is decided to make the camera aperture smaller than the projector aperture, my objection would be overcome, but in that event, I think the projector aperture now standardized by the Society is too small, as you are making smaller the usable area, and magnification must be needlessly increased.

If it be borne in mind that the Cameraman should see as near as possible the same picture through his camera as is seen by the individual when it is projected, I believe beneficial results will be obtained.

Sincerely yours,

GAM:B. G. A. MITCHELL

(Demonstration given with lantern slides and motion picture film.)

MR. CRABTREE: What will happen to the black border if the gate of the projector is cut so as to compensate for the keystone effect?

MR. JOHN JONES: You cannot eliminate the keystone effect if you have the black border.

MR. KROESEN: Will not the recommendation of the black border show up the defective negatives where the camera is somewhat unsteady? If no black border is used, the projected picture might not appear to be unsteady. I think the adoption of the black border on the film itself should not be accepted until a little further investigation is made. I was somewhat surprised that you did not show a portion of your film photographed with a steady camera and with an unsteady camera with the black border.

MR. JOHN JONES: The camera used was very unsteady due to the manner in which it was mounted and it was, therefore, very suitable for the purposes of this demonstration.

MR. KROESEN: I noticed that the camera was unsteady. If the projector aperture was a trifle smaller, it would not show the border on the film itself; it might have the effect on the audience of being more steady than it was.

MR. JOHN JONES: A picture taken with a steady camera with the aperture arranged to show a black border will be just as steady as though projected through an aperture.

MR. RENWICK: My impression is that at Roscoe the meeting was in favor of the black bordered picture, and that the matter was referred back to the Committee chiefly on the question of square or rounded corners. If that be still true and this meeting favors the retention of a black bordered picture, I suggest that the recommendation might be made more clear than it has been. The recommendation

is that the dimensions recommended would be those shown in Figure 4 on the screen except that in order to take care of square corners, it becomes necessary for the projector aperture plate to have square corners always; you may have square or round cornered apertures in the camera which is the only mechanism requiring two types of aperture.

MR. RICHARDSON: I believe I am safe in saying that a very large percentage of the high class theaters of this country and Canada have a projection angle far in excess of that recommended by this body. Under this condition it would, it seems to me, be impossible to apply the black border. It could only be applied where the projection angle is well within the maximum approved by this body.

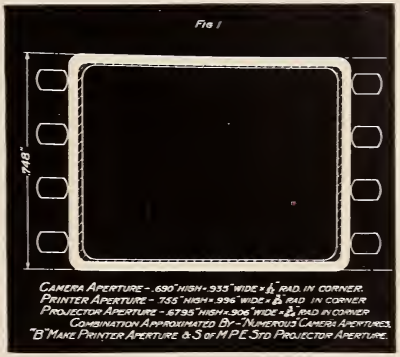
MR. RENWICK: I would like to remind Mr. Richardson that at the last meeting he expressed himself very strongly in favor of the black border. I think if the British Society can recommend the black border, there is no reason why we should not. If it will bring to the attention of the architects the necessity for more normal projection than they have been in the habit of permitting, it will be a good thing. If we cannot agree at this meeting, it will not help to turn it back again to the Committee because it is not evident what the Society wants to do.

MR. KROESEN: I want to analyze what will happen if the black border is definitely decided upon and adopted. You will find all projector manufacturers decreasing the size of their aperture, and we will find what we thought we had standardized on (projector machine aperture) will be no longer a standard, and the projector manufacturers will be forced to a smaller aperture to compensate for the black border.

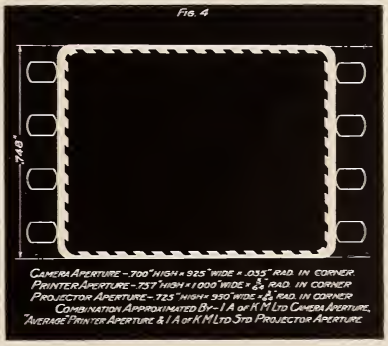
MR. HILL: One point brought out by Mr. Richardson is the fact that we have distorted pictures, which makes it necessary to correct the outline either by filing the aperture to a keystone or by using a black border wide enough to absorb the keystone effect. In order to do that with a picture having a black border printed on it, we must make a smaller keystone aperture or come in still further with the black border and the net result will be a loss in the effective area. I believe that will be the result of any action which would include a black border in the projected picture.

MR. JOHN JONES: We must not overlook the advantages of making the camera aperture the smallest. The cameraman can see exactly what he will get in the projected picture as everything showing inside the camera aperture would be projected. Aperture sizes can be standardized either with or without the black border so that those who want to use it can do so.

MR. PORTER: My feeling in this matter is that this Society and your Standards Committee should recommend what is good practice and not what necessarily fits present conditions. If we feel it is right, it is our function to recommend what will improve motion picture projection.



Camera Aperture - .690" high - .933" wide x $\frac{1}{16}$" rad. in corner.
Printer Aperture - .755" high - .996" wide x $\frac{1}{16}$" rad. in corner
Projector Aperture - .6795" high - .906" wide - $\frac{1}{32}$" rad. in corner
Combination Approximated By - "Numerous Camera Apertures,
"B" Make Printer Aperture & 3 of M.P.E. 3rd Projector Aperture.



Camera Aperture - .700" high x .925" wide x .035" rad. in corner.
Printer Aperture - .737" high x 1.000" wide x $\frac{3}{64}$" rad. in corner
Projector Aperture - .723" high x .950" wide x $\frac{1}{32}$" rad. in corner
Combination Approximated By - 1 A of K.M. Ltd Camera Aperture,
"Average" Printer Aperture & 1 A of K.M. Ltd 3rd Projector Aperture.

Mr. Richardson: I believe the black border is the right thing; I don't believe under present practice, however, that it can be used in many theaters. Whether we should cater to the wrong condition I don't know.

Mr. Griffin: I spoke at length on this subject at the last meeting, but I think the recommendation should be made. What we are trying to correct are the evils which exist. You can do this better if you standardize on the border because our aim is to get projection rooms in such a position that the best results are obtained. Unless you force the issue, you will continue to do the wrong thing, and if the film ten years from now all has a black border, the projection room must be moved and the pictures will be better projected, so I say let us recommend the practice.

Mr. Crabtree: It is not clear what is recommended; is it the condition given in Figure 1 or Figure 4, or both?

Mr. John Jones: The idea was to establish the size given in Figure 4 of Plate 2 to produce a picture with a black border with the exception that either round or square corners can be had. If not, Figure 1, Plate 2 is the one to standardize so as to give the cameraman the size of aperture to work to.

President Jones: In view of the alternative propositions, I think that the motion should be stated that we want to recommend the black border with or without the square corners. Mr. Griffin, will you accept that interpretation of your motion, that you recommend the dimensions with black borders with or without square corners?

Mr. Griffin: I do.

(Recommendation thereupon accepted.)

Mr. Porter: Now, we come to the question of standardization of external diameter of barrels of projection lenses. It is the opinion of the Committee that it is desirable to standardize projector lens mounts, if possible.

Your Committee finds that at the Rochester convention your Optics Committee studied the problem of standardizing the size of the barrels of projection lenses. They made the following recommendation to the Standards Committee, but we cannot find that any action was taken by either the latter or the Society.

This is a section from Dr. Storey's report made at that time: "A request was received from the Committee on Standards for a recommendation on the external diameter of the barrels of projection lenses. The Projection Machines Committee was asked whether all the projection machine manufactureres could be persuaded to agree on two sizes—one for a number 1 lens and one for a number 2. Pending a definite reply from the Projection Machines Committee, the Optics Committee has recommended to the Committee on Standards the adoption of two and one thirty-second of an inch for the external diameter of the barrel of a number 1 projection lens, and two and twenty-five thirty-seconds for that of a number 2 lens. The

diameter of the B lens standardized by the Incorporated Association of Kinematograph Manufacturers (London) is 2 1/16″.

There seems to be two chief factors in this problem as represented by letters which the Committee has from the Gundlach Manhattan Optical Company and the Bausch & Lomb Optical Company as follows:

GUNDLACH-MANHATTAN OPTICAL COMPANY

Lens Apertures

Rochester, July 6, 1922.

Dr. W. E. Story, Jr.,
c/o General Electric Company,
Schenectady, N. Y.

Dear Sir:

Your letter of April 5th to members of the Optics Committee has not been forgotten, but I have had so many other things to think about that I postponed answering.

Unfortunately I missed the Boston meeting so did not hear the discussion on the size of mounts for projection lenses, but I understand it was proposed to make a slight change in the diameters. There is no excuse for this whatever.

When we started making projection lenses about twelve years ago, there was only one size lens on the market for projection motion pictures. The diameter of the tube of this lens is 1.671,—about 1-5/8 in. In order to increase the working aperture to improve the illumination, we were obliged to make lenses at larger diameter, and for this reason when we introduced our No. 1 size projection lenses we established a standard of our own by making the tube 1-15/16 in. diameter and later, to increase the working aperture of lenses of longer focal lengths we made the No. 2 size and established another standard for the size of the tube of 2-25/32 in. diameter. These sizes, our No. 1 and No. 2, have been standardized by usage. No other concerns made these lenses for a long time, and now there are thousands of these sizes in use and other manufacturers are making the same size, so it would be absurd to try to change these standards at this time, and a trifling increase in the diameter of either size would serve no useful purpose.

Briefly, this is my objection to making any change from the existing sizes:

Looking ahead to the possibility of increasing the working aperture of lenses in the longer focal lengths we may possibly, to advantage, establish a standard for a projection lens of larger diameter than the No. 2 size or a larger amount than 2-25/32 in. diameter, so if the machine manufacturers wish to design their machines to accommodate such large lenses they will know what the diameter of the mount will be. However, there is no particular need of this because it is not likely that there will ever be any great demand for machines to accommodate lenses of larger diameter than 2-25/32.

I agree with you that it is not advisable for the Committee to concern itself regarding the quality of projection lenses now on the market, or the quality of any manufactuerers' products.

It would undoubtedly be an advantage if all machines using standard films were designed to accommodate No. 2 size projection lenses in focal lengths from 4-1/2 in. up, furnished in mounts 2-25/32 in. diameter, their full length, so the mounting of lenses with the rear combination smaller than the front can be avoided, and there should be nothing between the lens holder and film to interfere with using a lens of this size.

It would also be well for all the portable machine manufacturers to agree to design their machines to accommodate lenses of uniform size, say No. 1 size lenses in this instance. As it is now, a great many portable machines require lenses in mounts of different diameters so there is no uniformity at all in the size of the mounts, and in many cases the machines will not take a lens of large enough

diameter to give a reasonable amount of illumination. The lens seems to be the last thing they think of when they design a machine.

Yours very truly,

Dc.HG.-B. HARRY M. R. GLOVER.

BAUSCH & LOMB OPTICAL CO.
Rochester, N. Y.
Lens Apertures

Rochester, May 28, 1924.

Mr. L. C. Porter, Chairman,
Standards Committee,
Society of Motion Picture Engineers
c/o Edison Lamp Works,
Harrison, N. J.

Dear Sir:

Since the writer understands your committee will probably give consideration to the standardizing of projection lens apertures, and possibly will again consider the standardizing of projection lens outside diameters, I am taking the liberty of placing before you a few facts which I feel should be given consideration by your Committee.

First, the Bausch & Lomb Optical Company want it understood that they are desirous of cooperating in so far as possible in the standardization of lens diameters, and submit the following explanation for the variation in diameters of our Series 1 and Series 11 lenses from that of the other manufacturers.

When we designed the Series 1 and Series 11 lenses, the Nicholas Power Co., for instance, were not supplying lens holders or jackets for either of this size of lens for their machines, and since the lenses on the Simplex and Motiograph machines were not supported in the case of the No. 2 by their main barrell but by a reducing adapter attached to the rear cell, the matter of making the diameter of this lens the same as that of the Grundlach lens which at that time was the only other similar lens made, did not seem to be important, and we adopted for a barrel diameter a stock tubing and stock diameter of lens mount. Now that the Nicholas Power Co. are supplying on their improved type "E" machine a lens holder permitting the use of the full aperture of a No. 2 lens we readily grant the desirability of having the so-called No. 2 lenses all of a standard barrel diameter.

Our No. 2 lens as made at present, has a barrel diameter of 2-23/32 as opposed to a barrel diameter of other manufacturers of 2-25/32. We readily agree in the case of this lens to take steps to change this diameter of lens barrel to 2-25/32 as soon as manufacturing conditions will permit and in the meantime to supply to the Nicholas Power Co. or their distributors a split ring adapter so that these lenses will readily fit their mounting.

We would point out again that because of the manner in which the lenses are held on the Simplex, Motiograph and Baird projectors, that the main barrel diameter of the Series 11 lens is not important, but the increased diameter can quite as readily be applied to these machines when they become available.

2. At the time we designed and placed on the market our Series 1 Cinephor lens there was a demand from projectionists, particularly from Mr. Richardson, for a lens of this class with as large a lens diameter as possible to use on the projectors as manufactured at that time. Here again we would point out that at the time of the introduction of this lens the Nicholas Power Co. was not making a lens holder but the lenses were supported by a jacket screwing into a flange on the front of the machine head. Having in mind to meet the demand for increased lens diameter in this type of lens we, therefore, designed this lens of just as large diameter as was practical to fit on the Power's machine and to clear the interior mechanism in the case of short focus lenses. We, of course, supplied focusing jackets with this lens with a thread fitting in the flange regularly supplied with their machines so that there was no difficulty in anyone applying our Series 1 lens to a Power's make of machine.

In the case of the other makes of machines there was no difficulty in fitting this Series 1 lens because the lens holder as provided was of even larger diameter,

designed to take the reducing adapter of a No. 2 lens and the Series 1 lenses, therefore, could be fitted by means of a split ring adapter which we have included without fittings for adaptation to either the Simplex or Motiograph machines.

We simply want to emphasize again that in designing our Series 1 lens we had in mind to go just as far as we could in free lens diameter, and still fit to the machine as then available, and we felt we were justified because that meant a real advance in lens efficiency.

Our Series 1 lens has an outside barrel diameter of 2-1/32″ which we believe is approximately 3/32 greater diameter than that of the so-called No. 1 lenses of other manufacturers. Our lens has a free lens diameter of 43 1/2 mm. compared to a free lens diameter of 40 mm. in the case of one manufacturer and 39 mm. in the case of another. It seems perfectly obvious that this gain in free lens diameter is worth something.

The Boston number of the Transactions contains on page No. 188 the recommendation of the Standards Committee of which Dr. Story was then chairman, that the diameter of the No. 1 lens be 2-1/32″ and that of a No. 2 lens 2-25/32″. He also comments that there seems a little chance of a unanimous agreement on these dimensions because of the different interests involved. In the preceding number of the Transactions, namely that covering the Rochester meeting, Dr. Story as Chairman of the Optics Committee, submits a report on the question of No. 1 and No. 2 lenses on page 145. The writer feels that you should know that preceding that report of Dr. Story's, that he called together Mr. Glover, representing the Gundlach-Manhattan Optical Co., and the writer representing the Bausch & Lomb Optical Co., and that as a result of that conference Dr. Story made his report at the Boston meeting. It seems to the writer that if there is to be a standardization of these diameters that there must be a willingness to cooperate not only between the lens manufacturers but machine manufacturers as well, and some standard types of holders decided upon.

Since the Bausch & Lomb Optical Co. are willing to go to the expense of changing the diameter of their Series 11 lens to bring it up to that of other lenses of this class, it seems no more than fair that other manufacturers of a so-called No. 1 size of lens should be asked to increase their barrel diameters 2/33 of an inch, since there is no more involved in that procedure for them in the case of the No. 1 lens than there is for us in changing diameter in the case of the No. 2 lens. For the Bausch & Lomb Optical Co. to change the diameter of its Series No. 1 lens would mean not only a change of barrel and mounting diameters but a change in lens diameter, and the removing from the market a lens of increased free diameter which has generally been commended. It has been stated that common practice should constitute standards, and perhaps this argument should hold good so long as it does not retard development of the art. This certainly would be the case if the smaller diameters of the No. 1 type of lens should be adopted as a standard.

If there are any points which we have not made clear that you should like further information upon, we should be very glad to cooperate with you, and in closing may we point out the desirability of your committee pointing out to machine manufacturers the absurdity of using large diameter lenses such as the No. 2 size and diaphragming down that aperture by means of a reducing adapter in order to make it mechanically convenient to fit such a lens to their lens holder.

Yours very truly,

BAUSCH & LOMB OPTICAL COMPANY.

ILN:DS. By I. L. Nixon.

Your committee considers that it does not have sufficient data to make a definite recommendation at this meeting. Recognizing, however, the great need for standardization in this matter, we invite full discussion of the problem.

Mr. Richardson: I believe that either this Society or the Committee ought to call a meeting of representatives of the Bausch &

Lomb, Gundlach-Manhattan, and such other lens manufacturers as may seem desirable, also the Nicholas Power Co. and other projector manufacturers. By getting these men together with the Committee undoubtedly this matter could be settled and I don't think you will settle it in any other way.

MR. PORTER: It would seem to me that everything is clear and smooth so far as the No. 2 lens goes; Bausch & Lomb have agreed to go to 2 25/32 with everybody else making it; why can't we standardize on this and then take up the No. 1?

MR. GRIFFIN: I move that we accept this recommendation to adopt 2 25/32 inches as the outside diameter of barrels of projection lenses.

(Motion duly passed that outside lens diameter of 2-25/32 inches be accepted.)

PRESIDENT JONES: What is your desire with regard to the No. 1 lens?

MR. GRIFFIN: I don't think we can do anything at all with this at this meeting because Bausch & Lomb are the bone of contention, and I think they have made a good step in increasing the diameter. We objected to it because we had to make new adaptor rings, but now they have compromised and I think it should be possible to get the other manufacturers to increase the size of their barrels and working apertures, and I think this must be taken up as suggested before.

(Motion thereupon passed that the matter be referred back to the committee.)

MR. PORTER: The next point is "Standardizing width of film splices: The only definite information regarding desirable width of splices for positive or negative film that the committee has been able to collect was submitted by the Bell & Howell Co., and pertains to their film splicing machine. It was, therefore, thought advisable to hold this matter over until further information on the subject could be acquired." (Agreed.)

There is one matter which has been brought up by a letter which is not included in the Standards Committee report—the question of film core. This is a letter from Mr. Mitchell of the Mitchell Camera Company.

MITCHELL CAMERA CORPORATION
6025 Santa Monica Boulevard
Los Angeles, California

September 25, 1924.

Mr. Loyd A. Jones,
Edgewater Beach Hotel,
Chicago, Ill.

RE: FILM CORE

Dear Mr. Jones:

Undoubtedly at this meeting the question will again arise about the size core to fix upon as standard.

When we entered into the field as manufacturers of cameras, we found a varied condition in regard to the core. Every camera manufacturer used a different size spool on which to wind the film.

Cameramen using the Bell & Howell did not as a rule lose any film by tearing out the center, but left off the spool in the feed side and only used spools on the take-up end of the film. Wetting the spindle on the feed side generally stuck the film tight enough so it could be rewound. I followed this practice myself for a considerable time while employed as a cameraman. Some would rewind a roll when they knew they had to wind the film back.

The damage done to the film was after the days work was finished, being eager to get home, they would remove the spool from the exposed roll and then hold the center and pull the end until they had reduced the size of the roll sufficiently to go into the 400′ can supplied by Eastman. Many scratches resulted therefrom. (This operation is generally handled by the Assistant Cameraman.)

To overcome this tendency to be careless, we adopted a spool 15/16″ in diameter, so the roll as received from Eastman could be slipped on very easy, and when the day's work is finished, the roll will go back into the 400′ can without trouble. This permitted the use of smaller magazines on our camera, with a saving of weight.

A take-up was devised to drive this at the proper speed, using a 1″ hardened pulley with about a 10 degree angle groove on which the belt can't slip, all the slippage taking place at the magazine itself, on which is a round bottomed brass pulley 2″ in diameter.

With this arrangement, with a fast moving drive pulley, it works very successfully, and no loading up is noticeable as the take-up roll gets larger.

Since a standard which is not used is of no value, standard adopted should be of the most practical value, and work the least hardship on all concerned, so that it will be used by all, and become a *STANDARD IN FACT*.

Deploring the fact that I am not able to attend this convention in person, I trust you will give this matter the proper place before the interested parties.

Wishing this assemblage a very successful session, and thanking you for your kindness in presenting this matter, I am,

Most cordially yours,

GAM:B. G. A. Mitchell.

Now, your committee has not given any consideration to this matter because it was not received in sufficient time, but we should be glad to have the benefit of discussion on it.

Mr. Renwick: Inasmuch as this matter was also dealt with in the paper delivered by Mr. Vinten, I think it should be referred to the Committee on Standards and I move that this be done.

(Motion duly passed.)

Mr. Dennison: Could I make a motion at this time that the committee determine camera speeds?

(Motion duly seconded and passed.)

Mr. Porter: We shall be very glad to use our best endeavors to carry out your wishes, and I should appreciate it if Mr. Dennison will write us at considerable length.

We will now go on with nomenclature. "Arc" was eliminated at the last meeting; a definition for "retake" was referred back. "Request for a proper definition was sent to the membership in the S.M.P.E. bulletin, Vol. 1, No. 2, September, 1924, but to date, no replies have been received." To date we have received only one reply and that was from Mr. Chanier, who suggested—

RETAKE: The action of photographing scenes, or the negative resultant therefrom, when the negative or negatives previously obtained are unsatisfactory.

(Motion passed that the definition be accepted.)

MR. PORTER: Another definition referred back to us which was not printed is that for "scene." This was sent out in the Society's Bulletin with a request for a proper definition, and the only reply was from Mr. Chanier as follows: "Scene: A division of the story showing continuous action in the same locale or set and taken from the same point of view."

MR. RENWICK: In view of the difficulty we have had in trying to frame a satisfactory definition for "scene," I move that it be accepted.

(Motion duly passed.)

MR. PORTER: The definition of "film gate" was referred back to the committee at the last convention. We now recommend the following definition: "A movable element which, when in operating position, holds the film in register against the aperture plate, and is provided with an opening through which the projected light passes."

(Motion passed to accept definition for "film gate.")

The definition for "cooling plate" was also referred back to us for which we offer the following: "A shield, or baffle, composed of one or more plates mounted between the light source and the mechanism to prevent overheating the latter."

MR. ROEBUCK: It occurs to me that that might be improved a little to read: "A shield or baffle composed of one or more plates mounted between the light source and the mechanism and usually attached to the latter but spaced therefrom to prevent overheating the mechanism.

(Amendment seconded and passed.)

PRESIDENT JONES: The original motion before the house will appear as amended; all those in favor of the motion as amended signify by saying "Aye." (Motion thereupon duly passed.)

MR. CRABTREE: About the definition on "film gate," I think—

PRESIDENT JONES: That matter has been passed by this session and you are out of order unless you make a motion to reconsider the question of "film gate."

(Rising vote thereupon taken and passed that the definition of "film gate" be reconsidered.)

MR. CRABTREE: The recommendation is that the definition read: "A movable element which, when in operating position, holds the film in register against the aperture plate, and is provided with an opening through which the projected light passes." This applies only to projectors, not to cameras. I suggest that the definition be modified to read "and may be provided" instead of "and is provided" this covers cases where the gate has no opening.

Mr. Renwick: It appears to me that Mr. Crabtree's point is a very good one and I think the last part of the definition should be omitted entirely.

Mr. Norrish: I move that we leave out the latter part of the definition.

(Motion duly passed.)

President Jones: This, I believe, concludes the report of the Nomenclature and Standards Committee, and I think we owe them a hearty vote of thanks for the work they have put in.

NEW MEMBERS

The following additions have been made to the Society membership.

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MCRAE, DONALD A
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SENNER, ADOLPH G. A
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MEMBERSHIP NOTES

Apologies are offered for the following errors in the membership list as published in the last TRANSACTIONS.

Mr. A. E. Bradshaw is a member.

Mr. J. H. McNabb is a member.

Mr. Harry Sherman is an associate member.

Mr. E. K. Gillett was listed as 729-5th Avenue and should be 729-7th Avenue.

The Society is pleased to note that Mr. R. S. Peck is transferred from associate member to member.

The address of Arthur Price has been changed to

130 Benhoff Avenue,
Freeport, L. I.

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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CHICAGO, ILL.

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

Number Twenty

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CHICAGO, ILL.

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no 1

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1924-1925

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PRESIDENTIAL ADDRESS

Fall Meeting of the Society of Motion Picture Engineers

Chicago, Ill., 1924

Fellow Members and Guests:

IT GIVES me great pleasure to welcome you to the 19th regular meeting of the Society of Motion Picture Engineers. I do not need to tell you that these meetings are occasions of pleasure and profit to those who attend them. Our conventions have, in the past, been uniformly good and I know that this will be no exception to that rule. The local arrangements committee has been working very hard during the past months making the plans for our visit to Chicago and I know that we are going to be royally entertained.

When I realized that I would have to make an attempt to give a talk, diginified by the title of "Presidential Address," I cast about in my mind to determine what a president should say on such an occasion. After looking through the proceedings of several learned societies, I concluded that it is by divine right the privilege of the president to choose his own subject regardless of whether it has any relation to the immediate interests of the society or not. I am going to take advantage of this privilege and make a few rambling remarks which may, or may not, bear on the interests of this organization.

As I stated in the beginning, this is the 19th regular meeting of the society and, since it is our custom to meet twice a year, this means we are now in the tenth year of our existence. This is a relatively short time and I think we are to be congratulated on the progress that has been made within this single decade. Even though we are a young organization we have an illustrious ancestry and it may be of interest to turn backward for a few moments and see just how far into the past we can trace our family tree. Many people take great delight and pride tracing their ancestry back to the Pilgrim Fathers or to the time of William the Conqueror, so let us see if we can identify the beginning of the motion picture industry in those remote periods.

You are all familiar with what we may term the recent developments in scientific fields which made motion pictures possible. It was only a few years ago that Mr. C. Francis Jenkins built his first motion picture projector and we will not at present consider these recent developments but go farther into the past. I believe it is usual, in tracing a genealogy, to start at the present time and proceed generation by generation into the earlier centuries. However, we shall reverse this process and begin with the first date at which we can find any mention of anything resembling, even remotely, a motion picture.

Some months ago an interesting chronological table was published by Mr. W. Day* in which he gives many interesting references and I am quoting in part from this publication.

We find that the Chinese in 5000 B.C. indulged in shadow shows in which buffalo hide figures were projected as shadows or silhouettes upon parchment screens. The phenomenon of persistence of vision, upon which depends the possibility to produce motion pictures, was noticed and mentioned in the writings of Lucretius, 65 A.D., and this same fact was commented upon by Cladius Ptolemy in 130 A.D.

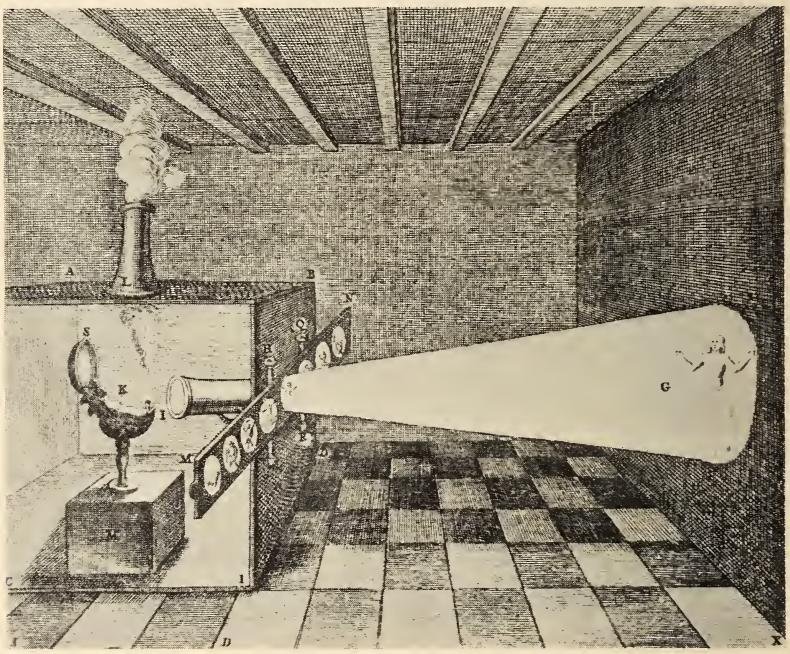

Fig. 1

The first lens of which there is any mention in existent literature, was formed by a glass globe filled with water. This is credited to Hero of Alexandria but no date is given for this work.

It is well known that the optical lantern, or projector, in some form, was used by the ancient priests and magicians in the temple of Tyre and throughout Egypt, Greece, and the Roman Empire between the period 4000 B.C. and 200 A.D. and it was by some such means that many of the divine manifestations, occurring in the shrines and temples, were produced.

* Trans. Opt. Soc. *24* No. 2, 1922-23, p. 69.

The optical lantern in its present form was invented by Athanasius Kircher at the Jesuit College in Rome, 1640 A.D. This was described and illustrated in "Ars Magna Lucis et Umbrae" by Kircher, the first volume of which appeared in 1657 and of which there are a number of copies still in existence. In Fig. 1 is shown a reproduction of a picture which appears in the second edition of the above work published in 1671. This shows Kircher's magic lantern and if we have an elastic imagination we will be able to see in the large box enclosing the light source and the lens a remote ancestor of the present projection booth, or as I should say in consideration of Mr. Richard-

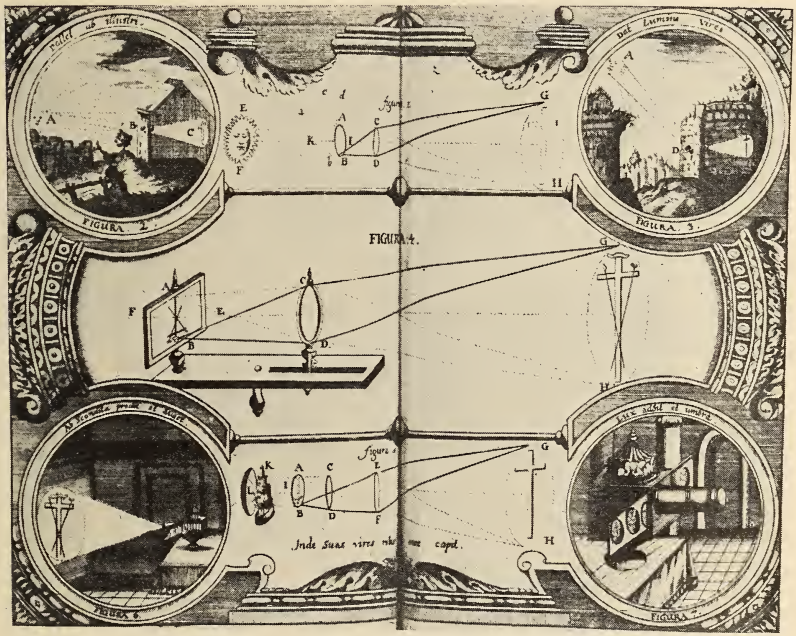

Fig. 2

son's feelings, the projector room. Following the work of Father Kircher there are many references in the literature to the projecting lantern and its evolution. In Fig. 2 is shown a reproduction from "Artificialus teledioptícus" by Zahn, 1685. Here we see not only the assembled projecting equipment but the geometrical optics are also clearly set forth. I do not know that Dr. Kellner will agree that the geometric optics shown therein are in entire agreement with the most modern conceptions but in any case the figure shows that the elements used in the projector at that time are essentially the same as those used at present. Fig. 3 is another illustration from Zahn's work (1685) showing the various suggested applications of the optical pro-

jector. The lower one is particularly interesting. The vertical rod, seen just above the body of the lamp house, extends upward through the roof of the house and terminates in a weather vane. This is connected by two gears, shown in the figure, in such a way that the image projected onto the wall of the adjacent room shows, at all times, the

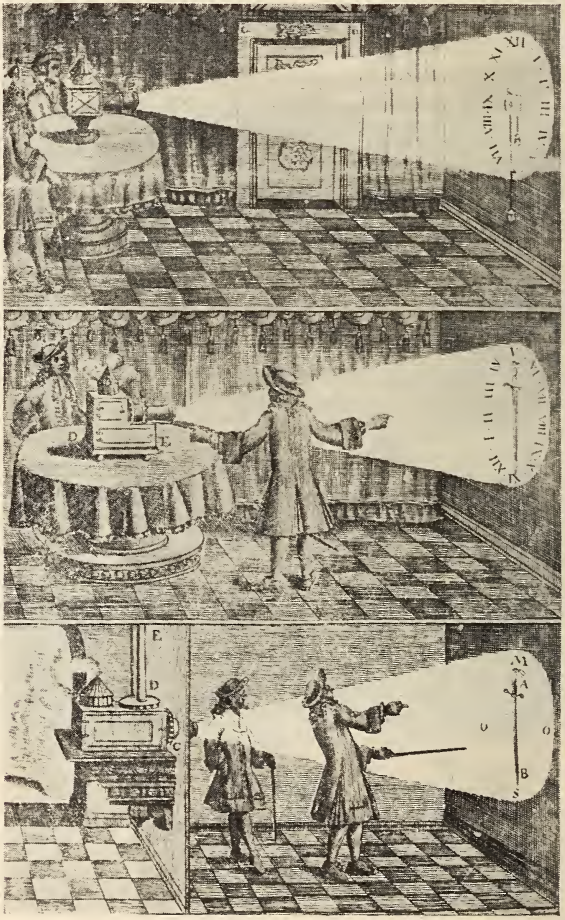

Fig. 3

direction in which the wind is blowing. In Figs. 4 and 5, also from Zahn's work (1685) are shown various suggested forms of the optical projector. In the lower right hand corner of Fig. 4 we see a type where the machine is supported on three legs and one can not help wondering whether or not this simple little device may not be the illustrious

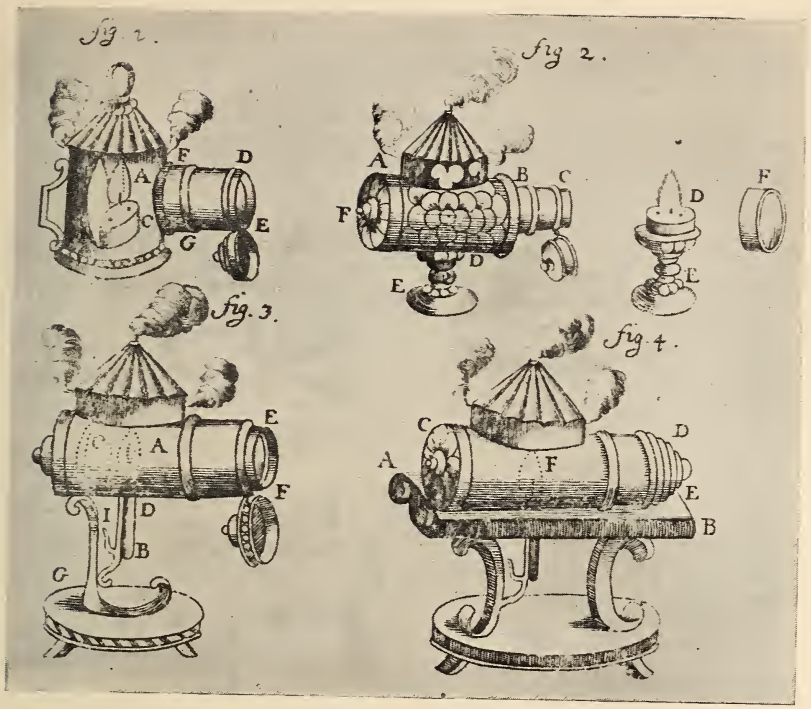
fig 1.
A
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fig 2.
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fig 4.
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Fig. 4

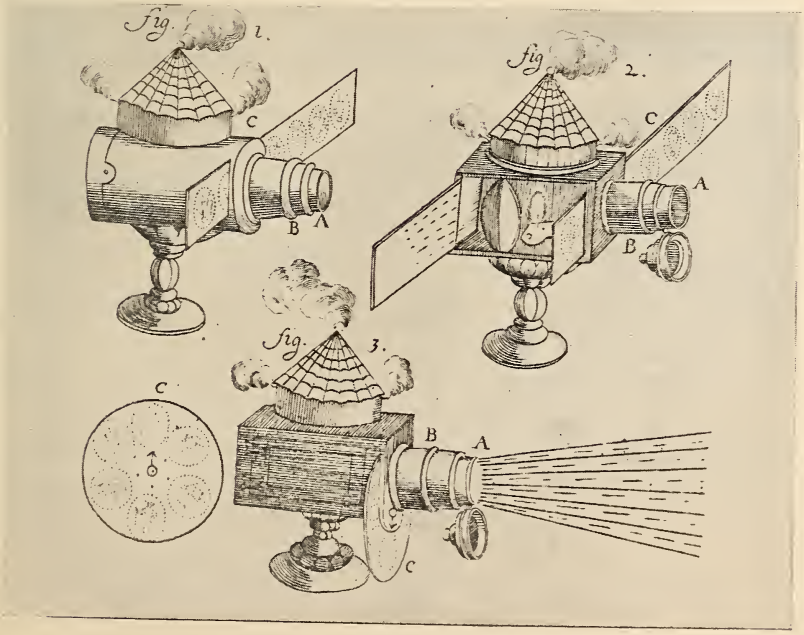
fig. 1.
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fig. 3.
C
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Fig. 5

forefather of the present highly developed Powers Projector. In Fig. 5 we see a somewhat different structural type in the supporting element and perhaps it is not unreasonable to suppose that this represents the ancient progenitor of the present Simplex family. Judging from the fumes emanating from the lamp house it must be equipped with high intensity arcs.

The Camera Obscura was first suggested by Friar Bacon in 1260 and Leonardo da Vinci gave illustrations explaining the theory and application of this instrument in 1490. Porta described the Camera Obscura quite fully in "Magica Naturalis" published in 1558 and in 1568 Daniel Barbaro first metioned the use of a lens with the Camera Obscura. The application of the light sensitive properties of silver salts to the production of pictures began about 1792. Many investigators worked on this subject and the precise chronological order in which the various results were obtained is rather uncertain.

From this period developments in the fields of science resulting in the production of motion pictures were very rapid and many of you are entirely familiar with this evolution. I will therefore not impose on your patience to follow the evolution from that time on. I hope that this very brief consideration of some of the more remote antecedents of the motion picture may be of some interest to you.

PHONOFILM PROGRESS

By Dr. Lee de Forest*

AS A PAPER on the technical side of the Phonofilm was read before your Convention at Atlantic City eighteen months ago, we believe it unnecessary to go very deeply into that phase of the subject now. You will perhaps be more interested in the advance made during that period of time.

Although no radically new improvements have been introduced, yet in a multiplicity of details, the Phonofilm apparatus, both for recording and reproducing sound with motion pictures has been improved, consistently and patiently improved.

Bell and Howell Cameras are now employed. The arrangements for passing the film with mathematical smoothness and accuracy before a slit actually reduced in width, are decidedly superior to the old. The camera has been made more silent and portable. Notable advance in this line was indicated when out-door Phonofilms of President Coolidge on the White House grounds, Senator LaFollette on the Capitol steps at Washington, and John W. Davis at his Long Island home, were secured.

Improved methods in printing and developing have been worked out. At the reproducing end a very great improvement has been achieved, especially in the Attachment for the Simplex projector.

A similar but simplified mechanism for use with the Powers projector is now under construction. We have already successfully adapted the Phonofilm Attachment to three leading types of projector machines—Simplex, Powers and Motiograph.

Over thirty theaters have been equipped for Phonofilms, and this work is now progressing at the average rate of two theaters per week, while more than fifty additional houses are under contract awaiting equipment, as fast as the necessary apparatus can be built and installed.

We find an ever increasing interest in the Phonofilm on the part of exhibitors all over the country. As more and more houses equipped demonstrate weekly the practical nature of the Phonofilm theater equipment, and the drawing power of this new type of screen entertainment, appealing to the ear as well as the eye, more and more theater managers are awakening to its possibilities in helping to solve their daily problem.

We are pleased to note that by far the majority of operators take kindly to the Phonofilm. The care of the apparatus has been reduced almost to the vanishing point. It is required only to close two small switches at the beginning and open these after running a

* Engineer 220 W. 42 St., New York City.

Phonofilm reel. In addition it is merely necessary to see that the storage battery is kept charged. We now install charging units (for direct or alternating current as the case may be) in each theater, with a simple double-throw switch for putting the battery on charge when not in use with the Phonofilm amplifier.

The operator usually appreciates the advantages to his house of the Phonofilm, and takes a keen interest in this new scientific addition to the equipment under his charge. He takes a natural pride in putting on the Phonofilm before his audience and strives to make it as attractive a feature on his program as possible. He soon masters the fine points of manipulation and adjusts the machine speed to give the proper pitch to a musical number and the intensity of his photo-electric lamp to give the sound volume best adapted for that particular record in his theater.

So we see that as in all branches of the radio art with which the Phonofilm is closely allied, constant improvements are being made. I have never claimed, as has been said, that the Phonofilm was perfect; but it is the unanimous opinion of the press and public that it is far nearer perfection than any so-called "talking pictures" so far produced. In our studio technique we have added many refinements during the past year and are now able to make satisfactory records of practically any sort of act that comes before us. Every problem in the recording of sound waves by light has been solved and satisfactory results are usually secured. The weakest link in the whole project is in the reproduction by means of loud speakers and the necessary horn for amplification. We freely grant there is room for improvement in that end, as every radio fan realizes, and we are constantly experimenting with the expectation that in the near future a means will be evolved to do away with the, at present, necessary horn. When that time comes I may come out with the statement that the Phonofilm is approaching perfection.

However, we do claim that our best reproduction is superior to the ordinary wax phonograph recording and also superior to that eminating from the radio loud speaker. We are now securing a purity of tone that is surprising and are reproducing every voice characteristic of the speaker.

Phonofilms of President Coolidge, Senator LaFollette, John W. Davis, and Chauncey M. Depew are striking evidences of this fact. Any person familiar with their respective voices can identify the speaker after hearing a single sentence. That enunciation is clear is easily found by our method of having a stenographer take down in short-hand each speech. We find an average of more than 95% which is probably as near correct as could be secured from the lips of the living speaker.

One year ago we were harassed by the constant cry that the people did not want talking-pictures. Exhibitors were pessimistic as to their value. We are most happy to state that this feeling has been quite generally eradicated. We have made contracts with the leading

chain exhibitors and have broken many box office records. Of course, we realize that in order to maintain interest we must continue to produce a constant supply of interesting numbers. But on account of the addition of sound we have virgin soil to draw from. The operatic and musical comedy stage abound with excellent material that is entirely unsuited to the pantomime pictures.

The question is often asked—Will the talking picture ever take the place of the silent drama? In my opinion the answer is "No," for the two forms of entertainment are essentially different.

The Phonofilm will never attempt to tell the same form of story adapted for pantomime nor will it draw its talent from the regular motion picture field.

When it is deemed advisable to produce Phonofilms of feature length, known success of the musical comedy and dramatic stage will be reproduced. Such productions will probably take the place of road-shows. This matter is being given careful consideration at the present time by leading New York producers. Perhaps many of you have heard the full orchestra accompaniment which we double printed on the first two reels of the "Covered Wagon." We believe that in the near future pictures will have their special orchestrations Phonofilmed which will enable the smallest exhibitor to give his patrons the same musical accompaniment now heard only in the Metropolitan first-run houses.

Taking it all in all, we feel very much encouraged by the result of the past years' efforts and believe that after five years of strenuous and often discouraging labor we are about to meet with our reward.

MEANS FOR THE PRESERVATION OF THE EYESIGHT OF THE PROJECTIONIST

By G. C. Edwards*

THE point that will at once attract the attention of the visitor to the projection rooms to-day, is the great number of men engaged in handling the projectors who are compelled to wear glasses, a much higher proportion being found in this craft than generally found in other occupations.

Upon inquiry it is found that in the majority of cases the glasses are prescribed by opticians to correct, in a greater or lesser degree, the same fault.

It is therefore reasonable to suppose that there is some condition peculiar to the craft of motion picture projection which affects the normal working of certain muscles and nerves of the eye. Let us see what factors might cause this trouble; it is a serious one, as without good eyesight it is impossible to have good projection.

1. The open Spot. This was the greatest offender we had to contend with, the muscles of the eye meeting it had to contract suddenly to an extreme degree which made it impossible to see the screen until the eye had accommodated itself to the screen illumination intensity, a matter of several minutes.

2. The semi-shaded spot. Here the condition was improved somewhat by mounting an eye shield at the cooling plate which protected the eye from the intense glare of the spot, but only when standing in one position. Later, a double eyeshield was put out by some manufacturers, taking care of the glare from each side and top, but left the bottom open, giving a strong reflected light from other portions of the mechanism. The eye is capable of accommodating itself, within certain limits, to any one intensity of light, but in this case we have two distinct light values of great difference which cause undue strain.

The solution seems to be the totally enclosed spot with glass viewing windows of a color permitting the spot to be clearly seen, and of a tone which will subdue the great contrasts in light values, this glass should be of a tint that will not permit the most injurious rays to pass, i.e.—the ultra-violet and the infra-red.

This spot shield should extend from the surface of the cooling plate to the cone with a sleeve adjustment to allow for different Y distances. It should be so mounted so as to be removable for cleaning without the use of screws or tools.

3. The next worst offender in our case is the lamp house peep hole-glass.

* Vice President American Projection Society, Inc.

Manufacturers from the beginning of the industry saw the necessity for a small opening in the lamphouse so that the progress of the burning of the carbon arc might be observed and the results of various adjustments noted. Little was thought of the possible danger to the eyes of the projectionist and these peep holes were fitted with glasses of a color, in many instances, which were a positive detriment to the nerves of the eye.

Blues—reds—violet—green and plain smoked colors were used singly and in combination; in the latter case the intense heat of the arc breaking one rendered the other worse than useless.

A system consisting of a pinhole throwing an image on to ground glass has also been tried and while it produced no eye strain, did not prove practical as a means of studying the arc. This is one of the problems which the manufacturer of projection apparatus should endeavor to solve with the aid of scientifically trained men, preferably optometrists who can furnish the data regarding the tints of glasses which will enable the arc and spot to be plainly seen, permit minute discolorations in the light to be rectified and be of a color which will stop the rays capable of injuring the eyesight of the projectionist.

These problems are well worth the attention of your Society as on the condition of his eyesight depends the value of the Projectionist to the great business in which we are engaged.

DISCUSSION

Mr. Richardson: I proposed to the projector manufacturers putting in place of what we call the "peep hole" a box with a pinhole ground and glass with an angle of 55° marked on this. The Powers Company did so, but did not arrange for the sliding glass. It gives you not only an absolute angle for accuracy but a pinhole photograph on the wall of the projection room, giving you a full face view of the crater and a view of the condition of the crater so that any projectionist can handle this lamp efficiently without looking through the lamphouse window at all.

Mr. Griffin: We did put this on for a while but it met with so much objection we had to take it off.

EFFECTIVE THEATER LIGHTING AND HOW TO GET IT

By G. G. Thompson*

THE attraction of light is inherent in the nature of nearly all living things. The butterfly dances in the sunlight; the moth is attracted to the glow of the evening lamp; fish are lured to the surface by the flare of the night fisherman's torch.

This attraction, since time immemorial, has been capitalized by the showman of all ages from the savage Congo witch doctor to the theatrical producers of Broadway.

The ancient priests of the sunworshipers built their temples so that the flashing beam of the rising sun, piercing through an opening in the temple wall, fell upon the altar and illumined the priest in his sacrificial rites. Savage dances are not practiced in the daytime, but around the flickering flame of fires, that the weird contortions of the dancers, enhanced by the shifting light and shadow of smoke and flame, may produce a stronger effect in arousing the frenzy of the tribe.

The old architects of churches knew the value of lighting and designed their sacred structures to create a sombre atmosphere befitting religious devotion. And even in the cathedrals of to-day, the flame of altar fire and candle is not only a symbol but an instrument by which the emotion of the congregation is heightened.

The merchants of our present age well know the value of lighting in dramatizing their offerings. Show cases and store interiors are illuminated not only to draw attention, but to render more attractive the goods displayed.

In a thousand ways, the theatrical value of lighting has been utilized to promote the purpose of the showman, whether he be savage or civilized, priest, merchant or theatrical producer.

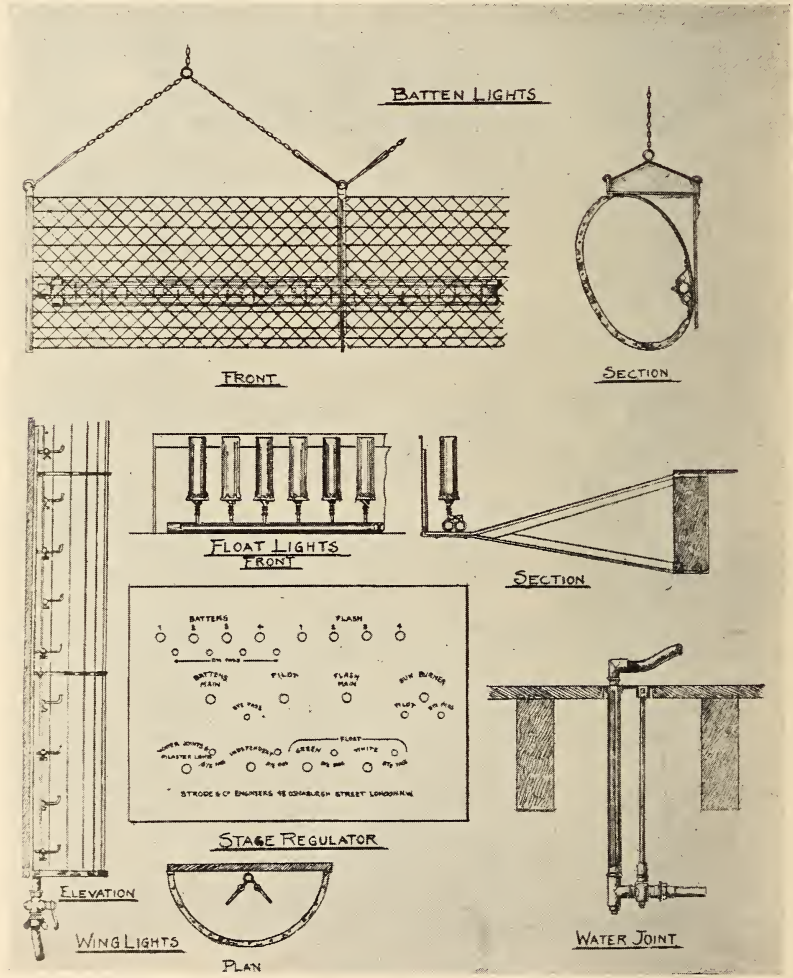
The earliest use of stage lighting we have been able to discover was in connection with the so-called Miracle plays introduced in the twelfth century in Europe. These plays were presented on rude platforms erected within churches and later in public squares or open fields. Actually, it was not until about 1400 that lighting itself came into vogue and it then consisted merely of sconces or candles burned before a shrine in connection with the performance. As these plays were scriptural in character, devils played a prominent part in the cast and their entrance was sometimes signalized by the burning of red fire to give local color to the scene.

About the beginning of the seventeenth century, plays began to be produced in buildings especially constructed for their presentation. Performances being given in the evening, it became necessary to

* Engineer of the Ward Leonard Electric Co. Mt. Vernon, N. Y.

provide artificial illumination of the stage and interior. For this purpose, cressets, lanterns and candles were employed, the cressets being receptacles of iron or other metal fastened to the wall and used to hold torches.

The use of foot-lights had been thought of half a century before



Details of gas lighting equipment taken from Building News, October, 1894. The illustration shows construction of batten lights, wing lights and footlights, and indicates layout of control board from which the dimming and brightening of the lights was manipulated.

this period but were not extensively used until about 1750 when David Garrick placed a row of candles below and in front of the stage of his Garrick Theater, masking the candles from the view of the audience by metal screens. Garrick also used side lights, now spoken of as borders.

The purpose of stage lighting in Garrick's time was merely to provide illumination of the players. Its value as a factor in the production of stage illusions had not then been thought of.

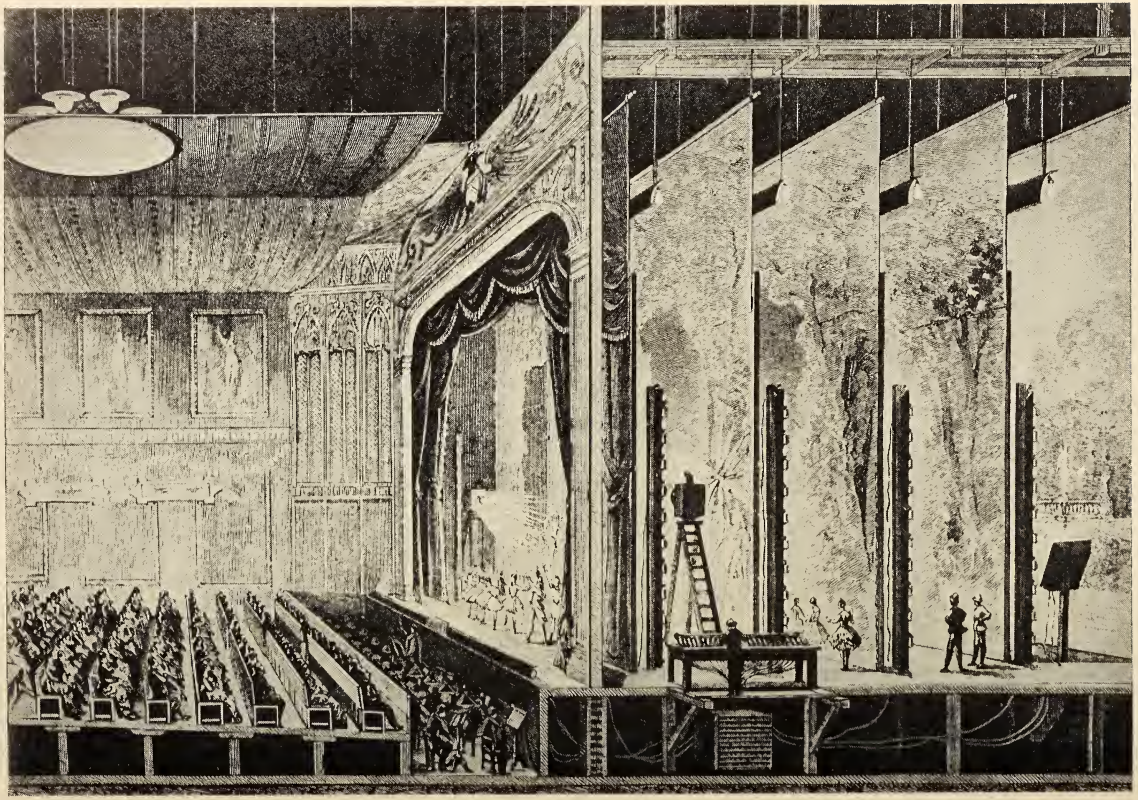
With the development of gas lighting, the possibilities of effective stage lighting began to be better appreciated, not only because the gas flame proved to be far steadier and more dependable than that of candles and lamps but because gas lighting could be so much more readily regulated. By means of gas lighting a row of lights could be simultaneously turned down or extinguished from the wings or back stage, whereas before gas was used it had been necessary for an attendant to separately turn down or blow out each lamp or candle. As may be imagined these proceedings interfered considerably with the illusion of the play.

With this larger command of lighting control, improvement in the utilization of light and shadow in stage productions rapidly evolved. In 1860 the calcium light came into general use for stage illumination, this light being produced by heating a block of lime to incandescence in an oxy-hydrogen flame. The use of a movable reflector in connection with calcium light constituted the first spot light by means of which the hero was given due prominence or stage effects produced—as light shining through a window, moonlight, sunrise, etc. The invention of mantle burners was soon followed by their use in footlights, proscenium lights, border lights and bunch lights.

About this time color lighting began to appear, its manipulation being provided for by a device for simultaneously drawing colored silk in front of, or away from, the lights.

The suffocating odors arising from the use of gas, the disturbing appearance of a rubber tube trailing from a stage moon, and numerous disasters by fire originating with open gas flames, and the oppressive effect of heat arising from the stage lighting, constituted serious drawbacks to the theatrical use of gas for illumination.

Accordingly, therefore, the introduction of the electric light inaugurated an era of unprecedented progress in the art of theater lighting. In 1882 tremendous interest among theatrical producers was aroused by the exhibition of a small theater completely lighted by electricity at the electro-technical exposition at Munich. Diffused light seems to have been first used for theater purposes at this theater. This light was emitted from arc lamps, the diffusion being effected by passing it through ceiling panels of ground glass. The walls of the theater were illuminated with incandescent lamps. The stage was lighted entirely with incandescent electric lamps and screens could be mechanically operated to change the color of the light from plain to red or blue. At this period much interest was created by a



Cross-section of electrically lighted theater constructed in Munich for the International Electro-Technical Exposition in 1882.

production of Faust in which a clever arrangement of electric circuits caused the clashing blades of Faust and Valentine to emit dazzling sparks of fire, tremendously increasing the excitement of the duel.

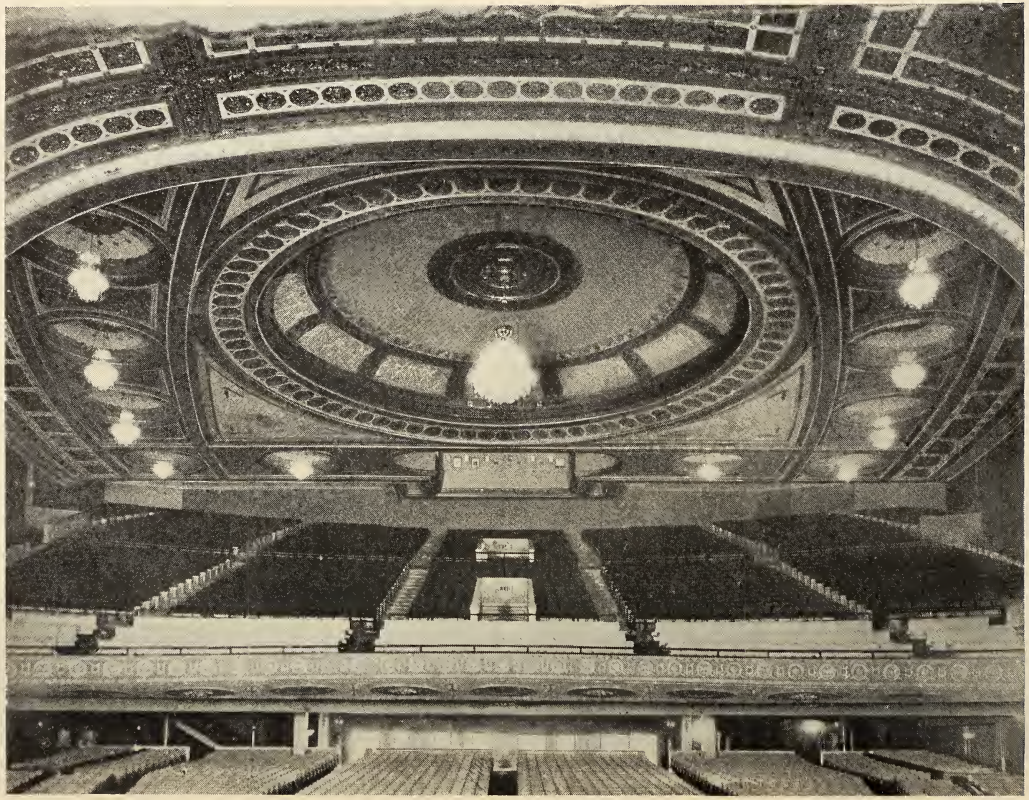
As was the case with gas lighting, the principal advantages of the use of electricity off the stage was the greater facility afforded for the control of lighting effects. This control is made possible by the case with which, through the employment of proper apparatus, the flow of electric energy may itself be regulated. This regulation is accomplished by the use of equipment embodying means for introducing a greater or lesser amount of resistance or reactance into a circuit, accordingly as the lights supplied by those circuits are required to be illumined to full brilliancy or softened down to any desired point.

In large theaters, including some of the very large motion picture houses of the greater cities, as well as the theaters exhibiting burlesque, musical comedy, variety, vaudeville, or the drama, are very extensive installations of such apparatus.

To understand correctly the proper application of theater auditorium and stage lighting to the respective needs of theaters featuring each of these types of entertainment, the requirements of each case must be separately considered.

The musical comedy, the variety show and the burlesque performance are all alike in principle as far as lighting is concerned. Lighting is used to heighten the effect of magnificence or of burlesque according to whether the effect of each given act depends upon sheer beauty or intentional absurdity. On the other hand, the whole aim of the lighting program in the production of a drama is to strengthen the illusion of the play. Realism is the constant effort of the producer. The lighting is made secondary to the actor instead of the players being merely a part of the scene in which the lighting is of equal or greater value, as is the case with a spectacular type of show. The vaudeville theater must be equipped to meet in a measure the needs of all of the foregoing types of performance inasmuch as the character of the different acts may range from tabloid musical comedies to one-act dramas with all sorts of miscellaneous acts in between, and a feature movie as a wind-up.

A theater which is suitable for dramatic productions is not generally suitable for a moving picture house on a competitive basis. This is particularly true of the lighting and control equipment needed for these different types of theaters. For efficient production of the drama a theater should not seat over 1500 people and the auditorium lighting may be of the simplest type. For this type of theater a combination of indirect and crystal fixtures are entirely adequate and the theater can be illuminated with this type of fixture at a much lower cost than with the cove and totally indirect system of lighting. For the stage the lighting system should be adequate to reproduce average interior lighting conditions and also colors and lighting to imitate natural conditions. This does not require the high intensity of



The Capitol Theater, New York City

illumination which should be provided for a musical review or vaudeville equipment where it is quite necessary to produce by means of lighting very beautiful and fantastic color settings. Adequate lighting should be provided for the dramatic equipment to produce general illumination in the modified colors and also to produce localized lighting which will be required in many different scenes.

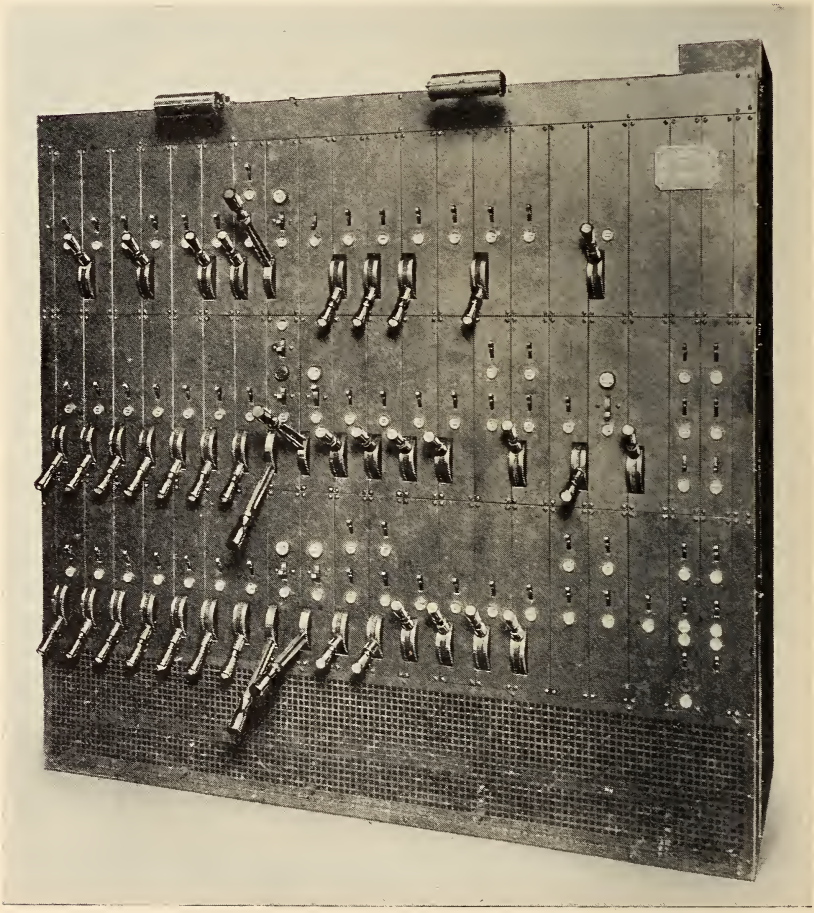
For musical reviews and burlesque a higher degree of illumination on the stage should be provided and if practical more attention should be given to the decorative features provided by the lighting of the house.

In the early days of the moving pictures exhibitors paid little attention to the lighting of the theater and very little if any illumination was provided. During the picture the lights were entirely eliminated and in many of the smaller theaters there was not sufficient light for reading during the intermission. Under present competitive conditions in the moving picture field, this condition has entirely changed. People expect to find the moving picture theater as beautiful as any other theater and some of them are more beautiful than the usual dramatic theatre. It has also been found that it is possible to provide a comparatively high degree of illumination during the projection of the picture without impairing its clearness but to do this it is necessary to have a properly designed lighting system. The essential feature is that the source of this illumination shall not be brighter than the light portions of the screen during the picture. This necessitates a totally indirect system of illumination for which the cove system is preferable.

It is also advisable to use color illumination as it is possible to provide a little more colored light than white light. Moreover, the use of colored illumination adds greatly to the beauty of the interior decorations if these colors are properly controlled. I am thoroughly convinced that there is a sound psychological basis for the success of the moving picture theater which is beautifully decorated and equipped with a good lighting system affording colored illumination. While the lighting of the moving picture theater should not distract the patrons' attention from the picture by violent and radical changes in color, the illumination can greatly beautify the interior decoration. This illumination should be very gradually changed, always maintaining a harmonious color scheme, so that patrons seldom see the house in the same light.

A great deal of interest and some controversy attaches to this question of special lighting effects as a psychological aid to the motion picture theater. We are all agreed that the brilliant illumination of the electric sign on the outside of the theater is an important factor in drawing the attention of the passing crowd to the performance within. There can be no question regarding the money-making psychology of electric light in that connection. But when it comes to the utilization of striking lighting effects within the theater, that is another problem.

Some theater managers have already experimented with color organs, consisting of electric switchboards manipulated like a console of an organ, by means of which a "score" composed of sequences of changing colors is "played," this arrangement of colors purporting to interpret in terms of color the musical score or motion picture which at the same time is being played or shown.

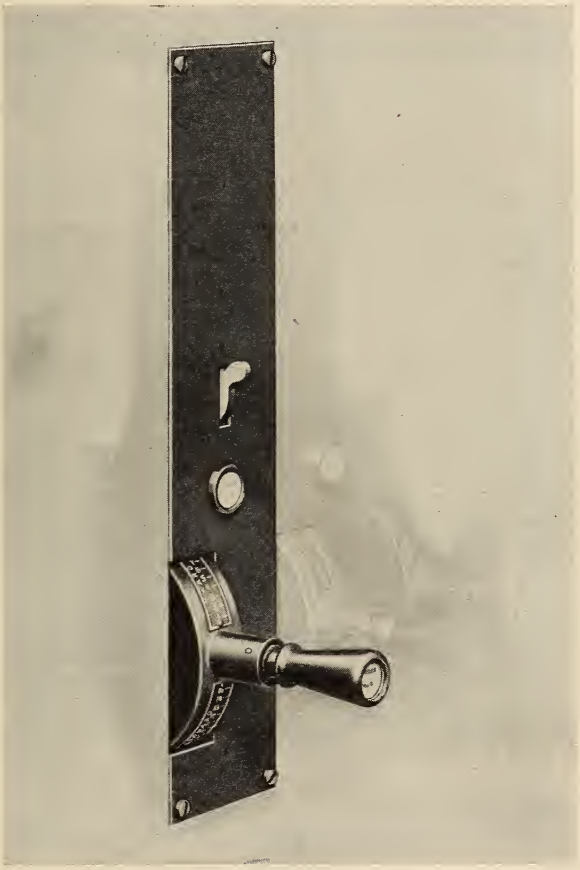


Controlite installed in Proctor's Grand Theater Albany, N. Y.

Another application of colored theater lighting for psychological effect is the use of "cool" colors in summer, and "warm" colors in winter. For example, a theater illuminated with blue or bluish-purple light will seem cooler and therefore more attractive and restful

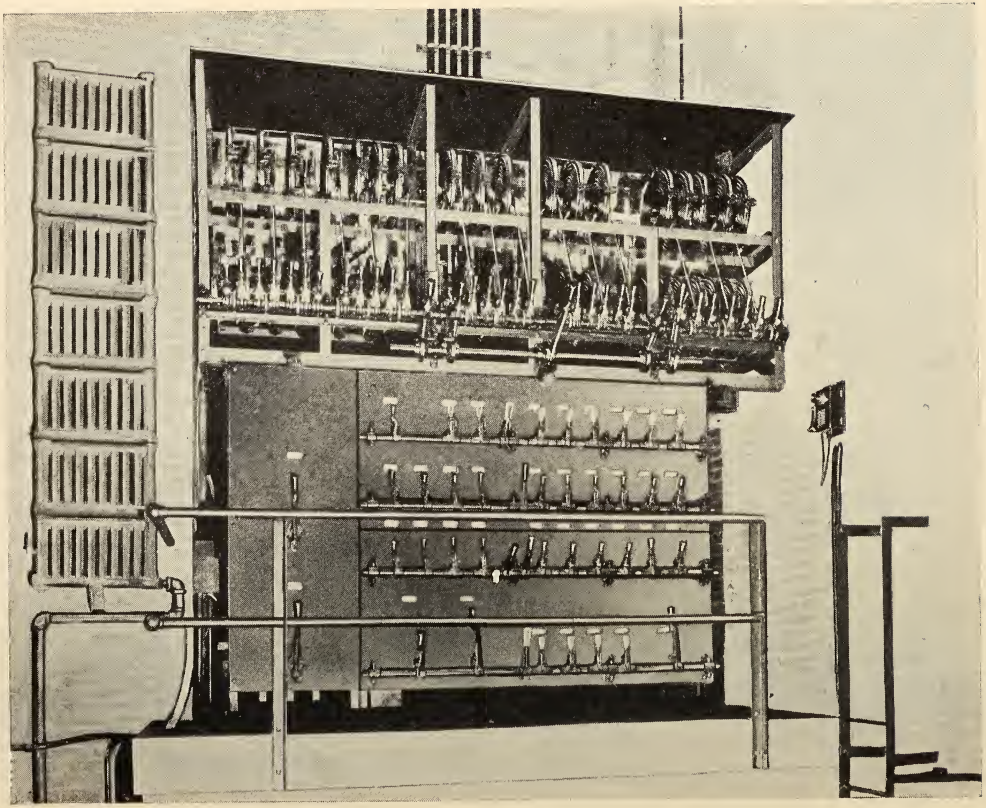
on a hot day or evening. Conversely, illumination with a warm color like rose or amber renders the theater more attractive on the cold days and evenings of winter.

As outlined above, the character of the performances to be staged imposes certain requirements on the theater and to obtain the best results the theater must be especially built to accord with the purpose



Dead-front panel for a Controlite unit showing the indexed light indicator

it is to serve. As there are only a few theaters in each of the largest cities in the country which limit their productions entirely to drama, practically all theaters, outside New York City and a few of the larger cities, should be built either for miscellaneous productions or for moving pictures, or for a combination of motion pictures and vaudeville.



Ward Leonard Dimmers (top of board type) installed in the National Theater, New York City

We cannot emphasize too strongly the need that when a theater project is first conceived the owner retain an architect who has specialized in the building of theaters. There are those in the United States who, because of their wide experience in this line of work, can give very valuable assistance, not only in the design of the architectural features but in the general arrangement of the theater and the proper selection of its location. Also, I would strongly recommend retaining an engineer who specializes on theater and stage illumination to supervise this portion of the work. Fortunately there are some engineers in this country specializing in this branch on a purely professional basis.

Before making specific recommendations as to the illumination of the theater, it is advisable to get the viewpoint of the owner as to the type of production which will be played, and also what clientele he is trying to reach. In too many cases the owner simply has the idea that a theater can be made to pay in a certain locality but has no intention of operating the theater himself and does not know the type of production for which it will be leased when completed. Also, they frequently express a desire to have the finest equipment for theater illumination that it is possible to produce, but as the building approaches completion, they try to cut this last item to the minimum possible and yet call the theater complete and ready to lease for production.

In the design of a theater to be used for moving pictures, either alone or in combination with other attractions, a totally indirect system of illumination should be used. With a totally indirect system of illumination it is possible to use the entire ceiling and some of the side wall as a source of illumination, and with this wide area the theater can be illuminated quite brightly without having the brilliancy of this source of illumination exceed that of the average white surfaces in the motion picture and thus make it possible to use as high a degree of illumination as .2 ft. candles without distracting from the clearness of the picture. The advantages of having this comparatively high illumination in the theater are 1st: That the patron may find his way about the theater without stumbling or the use of aisle lights—2nd: To relieve the gloom in the theater, and 3rd: to decrease the eyestrain. Colored illumination should be arranged for all theaters of this type and is being provided in the better classes of such theaters, particularly in the Central and Western States. It is also highly advisable to provide a sufficient amount of white illumination for a reading light during intermission.

It is quite customary to provide white and two colors, red and blue. This limits obtainable color effects to red, purple and blue. We believe much more beautiful results could be obtained if three primary colors were provided in addition to the white. The illumination during the picture should almost entirely in color. This illumination is at a very low intensity so that it is not necessary to have as high a degree of illumination in the color as in the white. However,

the absorbent factors of the present medium of color are so high that about the right results are obtained if the same wattage lamps are used in each color as in the white.

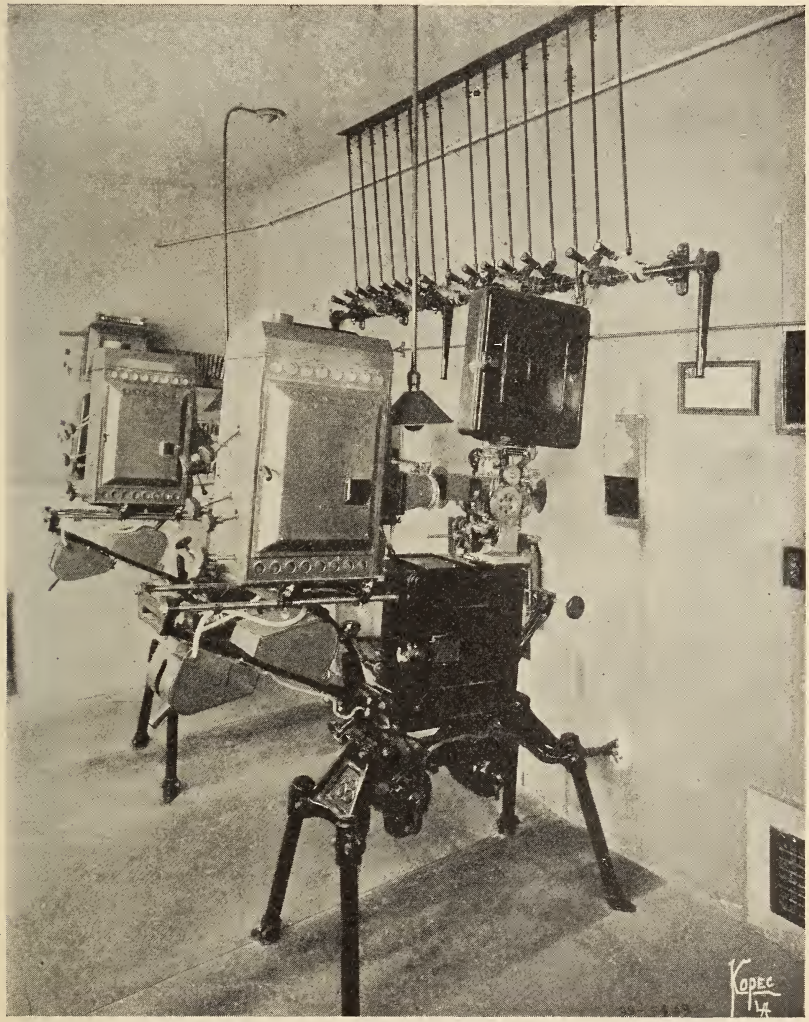
In order to attract attention and draw crowds it is highly advisable to illuminate the lobby very brilliantly. During the daytime the lobby should also be illuminated sufficiently so that it will not appear dull in comparison with the daylight outside. While very beautiful results can be obtained in the illumination of the lobby with coves, there is no real objection to the use of crystal fixtures and semi-indirect fixtures provided they harmonize properly with the decorative scheme. From the lobby in toward the auditorium the illumination should be gradually reduced so that one entering from the outside will not be blinded but will have sufficient illumination to see his way about even under the contrasts which are necessary during the projection of the picture. Good practice would seem to call for the illumination of the foyer near the lobby at about 5 ft. candles decreasing toward the theater and the lounge, mezzanine and rest rooms at from 2 to 3 ft. candles. Because of the variation of color in the interior decoration it is not possible to give any very definite figures as to the wattage required to produce this illumination but theaters have been very well illuminated with indirect fixtures, coves and soffit fixtures with from 10 to 20 watts per seat in each color.

The above factors may seem high to some but cover a totally indirect system. Using semi-indirect and with some direct fixtures it is possible to provide good effective illumination with as low as 4 watts per seat per color.

It seems to the writer that there should be some cooperative effort made to raise the standard of the illumination of the small standard moving picture theater. If sufficient attention is paid to the lighting during the construction of the theater, just as good illumination can be provided in the small urban theater as in the large moving picture palaces built in the larger cities. This should not require a very excessive installation or maintenance expense.

In order to provide beautiful and harmonious lighting in the moving picture theater, it is necessary to have an adequate system of control. It is not only essential to provide switches for the different sections of lighting, but suitable dimmers should be installed and arranged so that they can be operated either by the projectionist or by someone in close touch with him. It is very advisable to provide master levers to control the separate color groups and in the larger theaters a slow motion hand wheel should be furnished so that it is possible or the operator to gradually increase one color and at the same time reduce another. The switching and control equipment should be compact and convenient and, if possible, both the switching and dimming functions should be either combined in one piece of apparatus or arranged so the switches are adjacent to the dimmer control. In smaller houses where the lighting is regulated from the

picture booth, this control equipment is located as a part of the wall between the projection room and the motor generator or machinery



Operating booth in the Tivoli Theater, Los Angeles, showing operating handles to dimmer located above

room. One of the largest circuits on the Pacific Coast regularly mounts the light control switches in the front wall of the projection booth between the picture machine and arranges the dimmer control

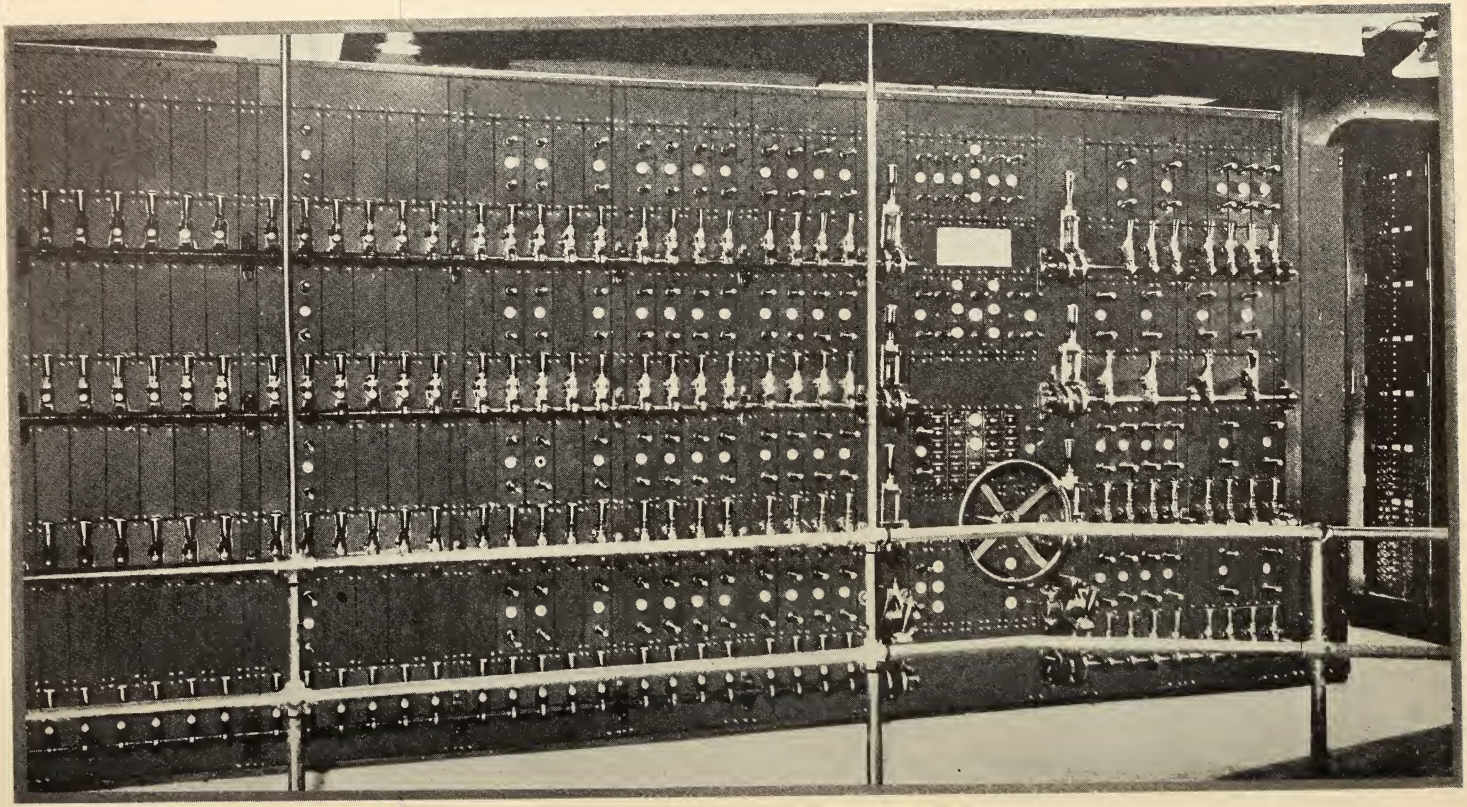
Interior Cleveland Auditorium, Cleveland, Ohio

handles on a long shaft extending over the inside face of this wall just above the port holes. The dimmer plates themselves are mounted above the ceiling of the projection room. Master levers are provided for operating any or all of the dimmers in unison. These are located between each of the machines so that wherever the operator is standing he can reach forward and adjust the lights. We consider this arrangement a very good one. The operator should be entirely responsible for good projection, and to be responsible for good projection he should have complete and accurate control of the lighting.

In the larger theaters where a full depth stage is provided for prologues and vaudeville production, a standard type of stage lighting should be provided which will give a general illumination of the stage with the white lights of from 50 to 80 ft. candles. This will require the use of borders about every 6 to 8 ft. in depth of stage and with a wattage of from 150 to 200 watts per lineal foot. For this type of theater we would recommend the use of the same wattage in each of the colors provided. This will make it possible to obtain very beautiful color settings with the use of comparatively inexpensive draperies and stage sets. The foot lights should be from 4 to 8 ft. less than the width of the proscenium arch and should have from 150 to 200 watts per lineal foot of each color. The proscenium strips on each side of the stage should be from 12 to 18 feet in height and carry 100 to 150 watts per lineal foot. An iron stand with an equivalent number of spot lights is frequently provided in place of the standard proscenium trough. The direction of these can be adjusted to meet special conditions. A series of incandescent pockets should be provided on each side of the stage, and also one in the center and one at the rear of the stage. It is considered good practice to provide a pocket opposite the end of each border, having one receptacle or each color provided in the border. The dimmers for these pockets should be arranged one in each color group. Where a complete stage is provided, it is advisable to locate the control for all lighting, both house and stage, adjacent to the proscenium arch at the right-hand side of the stage.

For the purposes of the average moving picture house, the resistance type of dimmer equipment will fully cover the requirements of adequate lighting control. For very large theaters where extensive lighting effects are to be employed, the reactance type is recommended. This is a recent development, the first installation being made in the Cleveland Auditorium.

As is well understood by engineers present, the principal elements of the resistance type of dimmer are the resistor plates, the movable contacts and the mechanical arrangement for manipulating the latter over the fixed contacts and the arrangement of the whole in a form most conducive to safety and convenience of operation. A dimmer is of course in continuous operation during the whole time the lights are dimmed. Consequently, in motion picture theaters, where the lights are dimmed by far the greater part of the time, it is especially important that the resistor elements in the dimmers employed should be capable of continuous duty with complete safety.



Main Switchboard, Cleveland Auditorium, Cleveland, Ohio

The most usual form of old type dimmer construction is that known as the top-of-board dimmer. With this arrangement the dimmer and switchboard were constructed independently, and the dimmers being mounted on top of the switchboard by the contractor. Since theaters in general have tended to demand more and more light, the dimmers have, of course, required a correspondingly larger space. The number of circuits in the switchboard, however, has not increased so greatly, and therefore the space required for the switchboard has not increased proportionately. This has resulted in many installations where the dimmers are mounted with three or even four rows of operating handles above the switchboard. Where the switchboard is built very compact so that it does not exceed a height of 4-1/2 or 5 feet, this has not been so objectionable, but in many instances the switchboards have been built 6-1/2 feet high so that the dimmer operating handle would sometimes be 7-1/2 to 8 feet above the floor. To operate such a board the stage electricians have had to first close the switches and then climb upon a bench two to three feet high to operate the dimmers. With an equipment of this character it is impossible to obtain good results. In many instances where the switchboard is particularly large, a balcony had to be built for the operation of the dimmers. This meant that either the dimmers were not used at all or an extra operator had to be employed on this balcony during the period of the show.

The most modern theater dimming installations comprise the combined switchboard and interlocking dimmer bank in which the switches and dimmers are interconnected electrically and mechanically. Each dimmer plate and its switch are controlled from a single operating handle. The dimmer switches open automatically at the dimmed position. The interlocking control permits the grouping of dimmers so that movement of a master handle or master wheel will control one or more dimmers as a unit, without interfering with the independent control of any single dimmer. Where desired, cross interlocking control may be provided which, by the movement of one handle or wheel, permits the dimming of any group of lamps while any other is simultaneously brightened. This cross-interlocking arrangement, it will be seen, is extremely convenient where it is desired to fade one color into another. In the most modern dimmer installations, the switchboard and dimmer bank structure is finished with a dead front panel, protecting the operator from chance contact with live parts, the operating handles projecting from the panel being adequately insulated from current-conducting members. These newest installations also are designed with numbered indicators in connection with the operating handles so that each circuit handle can be previously set at any desired dimming point and at the appointed time a master handle operated to flash on the entire group of circuits with all lamps dimmed to the pre-arranged degree of intensity. The indicator on each control handle also enables the house electrician and theater management to work out a lighting

program where elaborate lighting effects are employed with assurance that the lighting score will be carried out exactly as previously found most effective in the light rehearsals.

A summary of the features to be sought in up-to-date theater lighting control installation may be stated as follows:

The installation should comprise a complete switchboard and a complete dimmer bank in combination.

The dimmer and its switch should be controlled by one handle, an arrangement which makes it easy to operate without flashing the lights on or off, yet permitting the lights to be flashed if desired.

All dimmer-switch handles should be within easy reach.

All circuits should be subject to simultaneous control by moving a single handle or slow motion wheel. A slow motion wheel, it should be understood, is a hand wheel operated through gears to control interlocking master handles.

Any circuit or group of circuits should also be capable of operation independently or in unity with others.

Dimmer plates should be mounted directly in back of the control handles where they are readily accessible.

No dimmer plates should be in a parallel, thus reducing to a minimum the danger of burnouts of plates.

All fuses should be in one place, preferably at the rear of the control board.

Design of switch contact and arrangement of dimmer circuits should be such as to minimize arcing.

The dimmer control installation should be designed on an integral unit basis to facilitate any desired additions to or changes in circuits.

In planning the construction of a new theater or reconstruction of an existing theater, if dimming equipment is to be installed, the dimmer manufacturer should be called into consultation at the earliest stage of the proceedings. When requesting proposals for dimmer equipment, effective cooperation can be most promptly secured from the maker of the dimmers if the following information is at once submitted:

1. Voltage of lamp circuits.
2. Where dimmers are to be connected to two or three-wire circuits.
3. List of circuits to be controlled, with the name of each indicated so that the dimmer handles may be furnished with proper name plates.
4. The number of watts per dimmer.
5. The type of dimmer control; independent handle interlocking, cross interlocking, or remote control if interlocking or cross interlocking dimmers are to be used; the general arrangement, including the number and position of master handles, should be indicated by means of a rough sketch.
6. The dimensions of space available for dimmers should be given.

Where equipment is unusual, any requirements in addition to the above should be fully specified.

Much of the foregoing of course is of commanding interest only to the manager of the larger theater. In general, the lighting control requirements of the smaller motion picture theater are restricted to the dimming of the house lighting circuits commonly in use. The investment is relatively small and the effect of dimming conveying an impression of class to the audience is very definite. It is safe to predict that all motion picture houses except perhaps the nickelodeon, if there be any such left, will soon be equipped with dimming installations.

Notwithstanding the passing of the nickelodeon, it is certain that never before have the motion picture proprietors of America given the public such big value in amusement as is today being afforded by practically progressive house in the country. It is a source of satisfaction to the manufacturers of dimmer equipment that they have been able in some measure to cooperate with the motion picture theater proprietors in bringing about this result.

DISCUSSION

MR. RICHARDSON: I believe this Society has never before had a paper showing the enormous improvement that has been made in theater equipment so well as this one has done.

MR. POWRIE: I have been very much interested in the part referring to color illumination in the theater. In many theaters, they have a great many different colored lamps and screens. It might be possible to cut down the expense of many of the units if they could be reduced to three fundamental colors of red, blue-green, and violet, and I think this would be worthy of investigation, if it has not already been gone into.

READER OF PAPER: This has been considered and many theaters think only red and blue necessary but they are beginning to think that orange is required. Those three and white give all that is needed.

THE PROJECTION ROOM EXPENSE ACCOUNT

By F. H. Richardson*

IN VARIOUS papers presented to this society by the writer during past years, the fact has been emphasized that every operation in the production of a photoplay must perforce depend very largely for its effect upon the final buyer, the public, upon the manner in which it is projected to the theater screen.

For many years I have labored hard in the endeavor to impress upon this society, and upon the motion picture industry as a whole, the fact that ANYTHING WHICH CAUSES THE PHOTOPLAY TO BE LESS PLEASING TO THE THEATRE PATRON, MUST AND IN THE VERY NATURE OF THINGS WILL RE-ACT TO DECREASE BOX OFFICE RECEIPTS.

That fact is now, I believe, thoroughly understood by this society, and by a constantly increasing number of exhibitors, as well as by most producers. There still is, however, a very large percentage of exhibitors and theater managers who apparently still have a fixed idea that excellence in projection means either very little or nothing at all to the box office, and still others who do not believe that high grade projection is of sufficient importance to justify the added expenditure necessary to obtain it.

To argue with the men here present that a photoplay well projected is more pleasing and therefore has a higher box office income value than one not well projected, would be a mere waste of energy, because you all understand that fact. I believe you will all grant, as a basic proposition, that in order to secure the greatest possible box office return, a theatre must continuously and consistently present its pictures through the medium of high grade projection. If you do concede this, then immediately we are confronted with two questions: viz., (a) what various things are necessary in order that a theater present uniformly high grade projection, and (b) what amount of expense over and above the possible minimum is the exhibitor justified in expending in order to secure it.

Let is be clearly understood that by "High Grade Projection" we mean projection which will place upon the screen the highest possible entertainment value contained in any photoplay. Also we should understand that in this paper we deal only with projection itself, and not with those various other things which have to do with the show as a whole, such as music, screen setting, theater decoration, seating, ventilation, etc., etc.

Fix the fact clearly in your mind that projection, in all its grades, from the poorest to the best, is wholly a matter of cost. Any

* Motion Picture World, New York City.

theatre may have projection which will place upon its screen the maximum entertainment value, contained in any photoplay provided it is willing to pay the cost. This being true, the whole matter then resolves itself into a question of just to what extent added cost in projection will bring additional box office returns.

As a foundation for our discussion, I think we will all agree that projection room expense may only properly be increased above the possible minimum, when such increase will cause the box office to receive additional revenue, due to increased patronage caused by the increased excellence of the thing the theater patron pays to see—the picture—equal to or in excess of the additional expense incurred. Unless there is additional box office revenue which the exhibitor has reason to believe is due to improvement in the projected screen image, then the exhibitor very naturally and very properly does not feel that increase in projection room expense over and above the possible minimum is justified. As a business man he will only invest money where he has reason to believe the investment will be returned to him, plus a reasonable profit.

The purpose of this paper is to examine into the matter of projection room expense, seeking to determine, as nearly as we may, just what investment, over and above the possible minimum, is or ought to be justified from the standpoint of increased box office revenue.

Broadly, there are two possible extremes: viz., (a) the well constructed, well ventilated, properly located projection room, supplied with all necessary high grade projection equipment, and those conveniences necessary to the health and reasonable comfort of the men working therein, the equipment in charge of a projectionist or projectionists possessed of the technical knowledge necessary to the efficient, high grade projection of motion pictures, and with sufficient practical experience and energy to apply that knowledge intelligently.

Such a projection plant is expensive in first cost; also it is relatively expensive in operation, because of the fact that the high grade projectionist commands relatively high remuneration, and will only consent to handle equipment which is kept in good repair. A location for the projection room which is correct from the projection viewpoint is not always available without some sacrifice in seating space.

The other extreme is the small, cheaply constructed, poorly located, poorly ventilated projection room, without sanitary and other conveniences for the comfort of the men working therein, equipped with the cheapest possible machinery and optical appliances, the whole in charge of a projectionist possessed of slight technical knowledge and little energy or ambition to excel, or to even apply the knowledge he does possess in practice.

Such an assemblage comes cheap, insofar as first cost and upkeep be concerned, but an ever increasing number of theater managers and exhibitors are arriving at the conclusion, through costly experience, that first cost and upkeep are the only things in which it is not very expensive.

Let us now make detailed examination of projection room expense, with view of determining as nearly as may be just what expenditures represent good practice, and what ones do not, taking the probable effect upon box office receipts as our guide.

Naturally the first items for consideration are location, size and general construction, which we will consider in their order. It would be difficult, if not impossible, to offer anything in the way of tangible proof as to the beneficial effect of a projectionally correct projection room location. We shall therefore merely consider this item in the light of plain common sense.

When planning a motion picture theater, the architect may be governed by either one or two possible considerations in the matter of projection room location, (a) He may select a location where a room, commodious or otherwise, may be constructed at a minimum of trouble and expense, without marring the symmetry of the auditorium, or sacrificing seating capacity in any degree, but without regard to the amount of picture distortion such location will cause, or to what extent such location will involve inefficiency in the optical trains of the projectors. (b) He may select a location which will involve increased cost in construction, may mar the symmetry of the auditorium to some extent, or may involve a sacrifice in seating capacity, or may involve all three of these things. On the other hand this latter location will enable the projection of an undistorted picture, and the use of an efficient projector optical system.

Considering first the matter of picture distortion, while it is not possible to offer absolute proof that picture distortion operates to the detriment of box office receipts, still some things appeal to our common sense to such an extent that actual visible proof is non-essential to their acceptance by the mind. Ask yourself this question: IF A DISTORTED AND AN UNDISTORTED MOTION PICTURE WERE PLACED SIDE BY SIDE, WHICH ONE WOULD I LIKE BEST? WHICH WOULD BE THE MORE PLEASING?

Does your mind not instantly and automatically respond with: "Why, the undistorted one of course." If it does, then ask yourself this further question: WILL NOT ANYTHING WHICH OPERATES TO MAKE MORE PLEASING THE THING THE PUBLIC PAYS TO SEE, AUTOMATICALLY OPERATE TO INCREASE BOX OFFICE RECEIPTS? If an affirmative is your immediate mental reaction to that query, then, without tangible proof, the case is nevertheless proven to you, and the only remaining question is just to what extent seating may be sacrificed, and extra expense may be incurred in order to secure a projection room location which will permit of the projection of an undistorted picture.

In my opinion it is always possible to so plan a theater that the projection room may be properly located, with either no picture distortion at all, or only the permissible five per cent increase in picture height, without any serious sacrafice in seating space, and without appreciably detracting from the symmetry of the auditorium,

provided the architect first consider the requirements of projection and plan the theater in accordance therewith. There may be some additional expense involved in construction, and in securing proper ventilation of the room, but I believe we may safely assume that this moderate increase will be returned to the box office in a comparatively short while, by reason of the improved appearance of the undistorted picture over the distorted one.

Another factor which adds potency to our argument for additional expense in properly locating the projection room is the fact that, as a rule, the location which produces distortion is the up-high, away-back one, and this automatically compels the use of a long focal length projection lens, which is in itself inefficient, unless an expensive condenser be used, and may even be inefficient with such a condenser. Briefly this is because of inability of the lens to pick up the entire light beam, and the necessity for a large diameter projection lens, which has comparatively slight depth of focus, and which compels the use of a very wide rotating shutter master blade. These things mean waste of light, and if the distortion be heavy the stopping down of the projection lens diameter to secure added depth of focus, which in turn adds very greatly to the light loss. Also the wide rotating shutter master blade sets up additional flicker tendency, which operates to compel an otherwise unnecessarily high projection speed, which may work very serious injury to some parts of the photoplay.

WITHOUT FURTHER ARGUMENT, I THINK WE MAY CONCLUDE THAT ADDITIONAL EXPENSE IN SECURING A PROPER PROJECTION ROOM LOCATION IS EVEN MORE THAN FULLY JUSTIFIED.

The next consideration in projection room expense is the maximum and minimum amount which may be expended upon its construction. We may have a very small room—one just barely large enough to house the necessary equipment—and it may be constructed very cheaply, in which latter event it will probably be neither thoroughly fire proof or to any considerable extent sound proof On the other hand we may have a fairly commodious room, so constructed that it would be thoroughly fire proof and pretty nearly sound proof as well.

I think we may all agree, without argument, that the expense incurred in erecting a thoroughly fireproof, and as nearly as possible a sound proof projection room is always entirely justifiable. Some of the many reasons why this is so are that such a room gives adequate protection to the theater patron from fire danger, and prevents the annoyance caused by sounds from the projection room reaching the audience.

How many of you have, especially in the olden days, sat through an entire show with the annoying hum of a transformer, or the clicking rumble of a noisy projector intermittent movement sounding in your ears, distracting your attention from the screen, the annoyance

entirely due to a poorly constructed projection room. Would you not have immediately agreed that money expended to so construct the projection room that the source of irritation would be eliminated, would make the theater decidedly more attractive, and thus tend to increase box office revenues?

Expense incurred in the building of a commodious projection room, when space is available, you may or may not consider justifiable in the sense that it will operate to increase box office revenue. You will decide this question largely according to whether or no you believe men will produce uniformly better results when working in reasonably comfortable quarters, than when confined in cramped, crowded working space.

In considering this item remember that in the great majority of theaters the projectionist must remain constantly in the projection room from two to six hours. Is it not at least reasonable to assume that after any considerable time in the semi-darkness of a room in which there is no space in which to move about, a man will become mentally weary, and in consequence more or less prone to carelessness? His reaction is likely to be: "If they want high grade work, why don't they supply a decent place for us to work in!" It requires no effort of the brain to understand that such a state of mind is very likely to react detrimentally to the screen, and therefore to the box office. I believe you will agree with me that a reasonable amount of money expended in erecting a projection room of sufficient size to allow freedom of movement, or at least sufficient space to move around the equipment conveniently, will tend to improve the projection of the picture, and therefore will justify itself at the box office.

As to sanitary equipment—toilet and wash basin with running water—their lack tends to make the men uncomfortable, and therefore inclined to carelessness, with injury to screen results and to the machinery. Aside from health reasons, their cost is more than justified. I feel that it is not necessary to argue so obvious a thing.

We now arrive at the consideration of things concerning which it is possible to offer more definite proof, and arrive at perhaps somewhat more definite conclusions: viz., Projection room equipment (machinery etcetra) and its upkeep, lack of adequate consideration of which has, in my opinion, COST THE MOTION PICTURE INDUSTRY HUNDREDS OF MILLIONS OF DOLLARS IN THE PAST, both in damage to films and loss of revenue directly due to resultant injury to screen results.

We still are treated to the occasional spectacle of an exhibitor investing tens of thousands of dollars in erecting a really fine theater building, and other thousands in equipping it with expensive comfortable seats, a costly organ, an elaborate ventilating system, beautiful decorations, expensive carpeting for aisles and foyer, and then looking around for a good, CHEAP second hand motor generator, and two good CHEAP second hand projectors.

Not long ago an exhibitor in the middle western states wrote

me saying he had built a theater at the cost of $32,000.00 and was then installing furnishings, etc., at an additional cost of $5,000.00. The theater was scheduled to open just seventeen days from the date that I received the letter. COULD I TELL HIM WHERE HE COULD SECURE A SECOND HAND MOTOR GENERATOR SET, AND TWO GOOD SECOND HAND PROJECTORS, CHEAP? I replied, advising him to secure a second hand DeVry, which would be much cheaper than a professional projector, and he would then require no motor generator. He would only need one, since doubtless his audiences would not mind waiting while the boy—for surely since a boy would be cheaper than a man, he would not employ a man, for, to him, such an apparently unimportant item as projection—changed reels, provided he ran an explanatory slide. I heard no more from him. I did not care to. I relate this incident to this society merely as illustrative of the amazing unintelligence with which the motion picture industry still has to contend.

Let us now consider the matter of whether the exhibitor is justified in replacing old projectors with new, up-to-date ones. Let us assume that in a certain theater the admission price averages twenty-five cents for all seats, and that there are a total of 700 seats. Let us further assume that this theater gives four shows each day, in which case it has a total of $700 \times 4 = 2800$ seats for sale each twenty-four hours.

This theater has, we will suppose, two motion picture projectors which are old type and badly worn, and a motor generator set which is well past its prime of usefulness. The management claims it cannot afford to replace these machines with new equipment so long as they are "giving good service." Let us examine into that matter, in the light of reason and common sense, carefully remembering that "good service" is a relative term only.

Let us assume that two new, up-to-date projectors would cost him in round numbers, a total of $1,600.00. Let us further assume that the new projectors will last only three years, at the end of which time they would be without further value. In other words the management will, after three years of use, throw the projectors in the scrap heap as having no further value.

This means that the management will have $1,600.00 invested in projectors for a period of three years, and that these projectors must not only earn an additional $1,600.00, plus $512.00 as interest at eight per cent on the investment, in order to clear themselves, but must return an additional sum over and above that, as profit, in order to justify their installation.

During the three years the projectors must return a total of $2,112.00 in added box office receipts in order to pay for themselves, and in addition pay eight percent interest on their costs.

This seems quite a large sum of money until we examine the facts. The average price of seats in this theater is, we have assumed, twenty-five cents. There are (365×3) 1095 days in three years;

hence, it will require an average increase in daily income equal to (211200 cents ÷1095 days) about 192½ cents to pay the total cost of the projectors and interest on the money. Remembering that if the theater is an average one it will have an average of at least 800 of the total 2,800 seats unsold each day. Will any man contend that new up-to-date projectors will not, with the application of the same skill and knowledge the old ones received, give a sufficiently better projection to cause enough additional patronage to fill MORE than eight of those unsold seats? If this appeals to your mind as sound argument, then we may decide that projection room expense for replacing the projectors once every three years is fully justified.

This same argument applies to upkeep in the shape of repairs for the projectors. It may be presumed that, taking theaters big and little, one hundred dollars a year will be ample to keep the projectors in very good condition, but to be liberal let us set the sum at $150.00 per year. This is less than fifty cents per day, and surely projectors in good repair will put a sufficiently improved projection on the screen as against projectors in poor repair, to increase patronage by the sale of two additional seats a day. To think otherwise would, it seems to me, be to pay the public a very poor compliment.

In the matter of motor generators, the same general argument applies, except that the loss in their case may be that of an entire show, with a crowded house, because of a break down of the old, decrepit motor generator. One stoppage may cost more than enough to pay interest on the investment in a new machine for many years. In large theaters it may equal the price of a new motor generator.

IMPORTANT: REMEMBER THAT IN CONSIDERING SUCH MATTERS WE ARE NOT MERELY EXAMINING THE PROBABLE EFFECT UPON AN INDIVIDUAL SHOW, BUT THE EFFECT ON THE BOX OFFICE OVER AN EXTENDED PERIOD.

Our whole argument is based upon the assumption that the public will, other things being equal, prefer the theater where they may see a perfectly projected picture—that they will patronize such a theater in preference to one in which the projection is poor. To make the matter unmistakably clear let us consider two adjoining theaters, one of which is known to have perfect projection and the other a projection less excellent. Our claim is that the theater with the better projection will have the better patronage, except when the one with less excellent projection has an attraction of greater drawing power, nor does the possible difference in drawing power of attractions in any degree invalidate or detract from the potency of our argument.

As regards the amount of expense it is advisable to incur in the use of electric energy in the endeavor to place a satisfactory picture upon the theater screen, or the type of light source it is advisable to employ—high intensity arc, ordinary arc, mazda or reflector type arc—it is difficult to make even an intelligent guess, because of the fact that so very much depends upon the conditions encountered in

each individual installation. All we may say with confidence is that any expense incurred in improving the light source in a way which will place upon the theater screen a sufficiently improved picture to attract additional patronage is justified, assuming, of course, that there is possible additional patronage to which to appeal.

We may, further remark, however, that except in the village theater where possible patronage is strictly limited, and where a very brilliant illumination will serve to emphasize the faults in the old film usually used, it probably always pays to use a sufficiently brilliant illumination to place upon the screen all details contained in the film photograph. It may also be said that in large theaters it will always be justifiable to use a light source of sufficient brilliancy to make all picture details readily discernible to patrons in the back rows of seats.

We now arrive at the last, and in some ways the most important item of them all: viz., What amount of money are we justified in investing in skill and knowledge in the projection of pictures? Put in another form; is money in excess of the possible minimum invested in superior skill and knowledge in projection likely to return a profit on the investment?

In the past the practice has largely been to invest only the absolute minimum in these items. As a rule the industry has offered little, if any, monetory incentive to men to excel in projection, and it has offered very little other incentive. It has been inclined to foster the idea that little real knowledge or skill is needed to place the finished goods of the industry before its buyer, the public.

In this connection we may assume that men engaged in projection are no different from the rest of humanity in that it requires some real incentive to bring out the best there is in them. Just as with other professions and vocations in life, some real incentive is needed to bring out the best there is in the projectionist with the exception of an occasional individual who has the germ of progress implanted in his soul.

If we admit the correctness of the statement that it requires at least some degree of expert skill and knowledge to place before an audience the highest entertainment value it is possible to obtain from any set of films, we also admit that men possessed of such expert knowledge and skill ought to be encouraged: also, it follows that the greater the amount of knowledge and skill possessed by an individual the higher is his value to the theater.

I think we may all agree upon the foregoing, and from this point it is but a slight step forward to assume that a reasonable amount of money invested in encouraging real projection ability (which includes, skill, knowledge, ambition and the energy necessary to apply them in practice) is more than likely to prove profitable in the end. I believe there is nothing in all the realm of industry so completely discouraging to the really good man as to see a man or men of inferior energy and ability receive equal remuneration with him for the same

work, the more especially when that work is performed in an inferior manner. Yet we see that very thing in projection rooms all over the country, because of the fact that where an organization has set up a minimum of pay designed as the remuneration for its poorest men, it has been adopted as both maximum and minimum, and a dead level is thus set up for good and bad alike.

It most emphatically is not the intent or purpose of this paper to discuss the matter of wages, except so far as is necessary to point out the evil of the dead level, and the injury it works to the industry through discouraging capable men from advancing in knowledge and skill in the projection of motion pictures effectively and efficiently.

I firmly believe that money invested by exhibitors in the form of higher remuneration for men who give evidence of energy, skill and knowledge in projection will, in the end, be found to be thoroughly justified projecting room expense.

In closing, let me say that this has been a difficult subject to treat adequately, and at the same time avoid the appearance of "grinding some one's axe," which most emphatically is far from the intention of the author of this paper.

I have tried, perhaps not altogether in the best way, to show that any projection room expense which tends to project a better picture, or to project the picture more efficiently, is a justifiable expense. If I have given you anything which may be of value to this Society and the motion picture industry, I am well satisfied.

DISCUSSION

MR. HILL: I am very glad to hear Mr. Richardson again on the value of projection in terms of box office receipts. At times we have been astounded by the financial gain which has come to us through improved projection. In some instances, when we placed new equipment in operation, the box office receipts have doubled.

TRANSLUCENT SHUTTERS

By Lester Bowen*

WE HAVE recently made a series of tests with several translucent and semi-transparent shutters and we have selected from among these shutters three tests which will best serve to illustrate the effect which is produced on the screen when using shutters of this kind. The equipment used in making these tests consisted of a G. E. Incandescent Lamphouse, using a 900 watt Mazda Lamp at 30 amperes with cinephor condensing system. A line screen was placed at the aperture and focused on a translucent screen, using a cinephor 7.75 E. F. No. 2 lens. The screen image was $18\frac{1}{2} \times 24\frac{1}{2}$ in. The image was photographed from the rear of the screen and we have prepared a series of illustrations from the photographs taken.

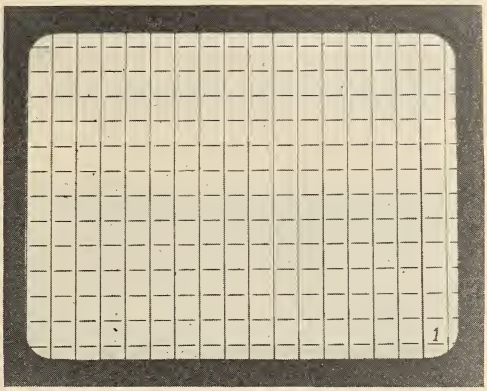


Fig. 1

Illustration No. 1 shows the line plate projected on the screen without shutter.

Illustration No. 2 shows the line plate projected on the screen with an opaque shutter revolving in the light ray. Compare this illustration with illustration No. 1. This comparison shows very plainly that the opaque shutter does not in any way affect the definition of the screen image.

Illustration No. 2A shows the image of a piece of test film projected on the screen, using an opaque shutter. This illustration shows plainly by comparison with illustrations Nos. 1 and 2 that the shutter under operating conditions with test film does not affect the definition of the screen image.

* Designing Engineer, Nicholas Power Co. Inc., N. Y. C.

These three illustrations will serve as a basis of comparison between the result on the screen when using an opaque shutter and the results secured with the three shutters selected. It might be noted at this point that during this series of tests the projection lens was not disturbed after the line plate had been sharply focused, except in cases where the test film was used. At the beginning of the film

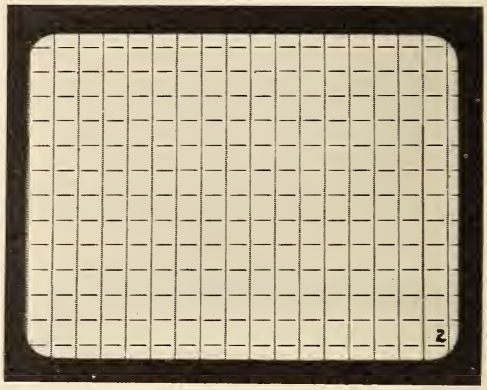


Fig. 2

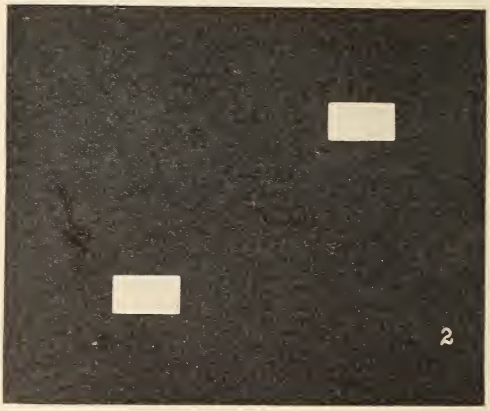


Fig. 2A

tests the test film was focused sharply, and all the film tests were completed without disturbing the projection lens. The differences in definition which will be noticed were entirely due to the shutters used in the various tests.

The claims made for the different shutters are an increase of illumination on the screen and also reduced flicker. The increase

in screen illumination is secured by perforating the shutter blades or by making the shutter of some transparent or semi-transparent material which will permit light to pass through the blades. It is possible to allow a considerable amount of light to pass through the balance blade without injuring the screen picture. If, however, the balance blade *is* to permit any considerable amount of light to pass.

Fig. 3

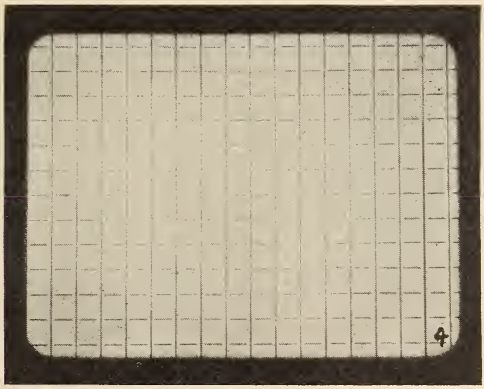


Fig. 4

it is also necessary that the cover blade pass a certain amount of light to the screen in order to maintain a balance. Otherwise, a very noticeable flicker will be caused, and in order that the movement of the film picture may not be visible, the cover blade must be so constructed that the screen definition will be destroyed. This, of course, means that the light which passes through the cover blade will be

unevenly distributed over the screen surface, the result being that the definition and contrast of the screen image is considerably damaged. This is very plainly shown in the series of illustrations which we have prepared.

Test No. 1.

Illustrations Nos. 3, 4, 5 and 6 were prepared from a test made with a shutter having a perforated section in the center of the cover

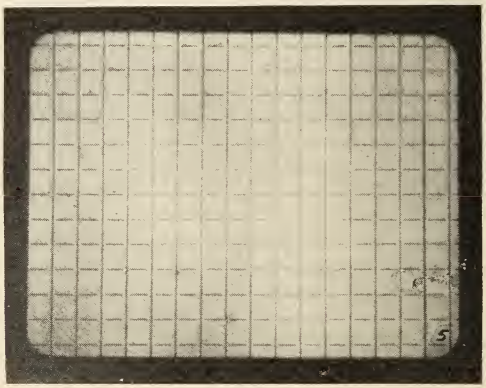


Fig. 5

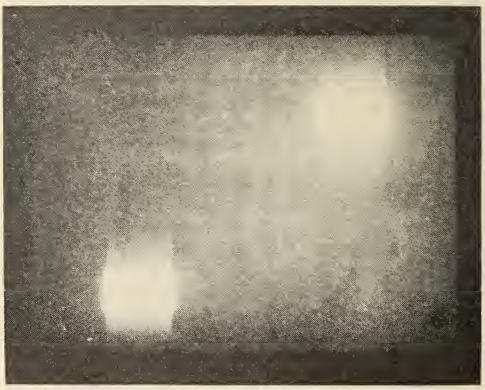


Fig. 6

blade about 1-1/2″ in diameter and covered with a thin lens and having a red screen inserted between the shutter and the lens. In the flicker blade a circular opening about 1-1/2″ in diameter was cut and a green filter placed in this opening.

Illustration No. 3 shows the result on the screen with the cover blade stationary in the light ray. This illustration shows plainly

that the screen image is entirely destroyed and that the light which passes through the shutter blade is very unevenly distributed over the screen surface.

Illustration No. 4 shows the effect on the screen with the balance blade stationary in the light ray. In this illustration the image of the line plate can be plainly seen although by comparison with

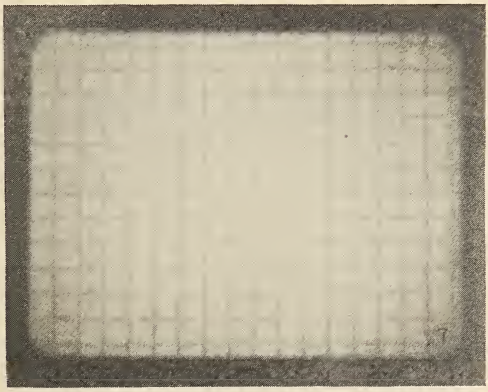


Fig. 7

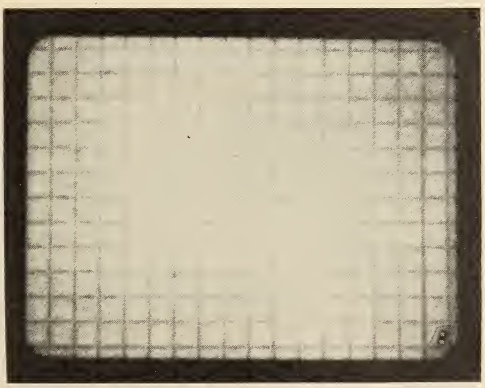


Fig. 8

illustration No. 1, it is evident that the definition of the screen image is noticeably damaged.

Illustration No. 5 shows the effect produced with the above described shutter revolving with the openings between blades closed. This illustration shows the screen image as projected through the shutter blades only, and this represents what is added to the screen image by the use of this type of shutter, and it is very evident that

the screen picture is not improved by the addition of the hazy image which is projected through the shutter blades

Illustration No. 6 shows the effect on the screen when projecting a piece of test film with this shutter. This illustration shows the effect on the screen under actual operating conditions with test film. The lack of definition is very noticeable and travel ghost can be plainly seen above and below the rectangular perforations in the test film.

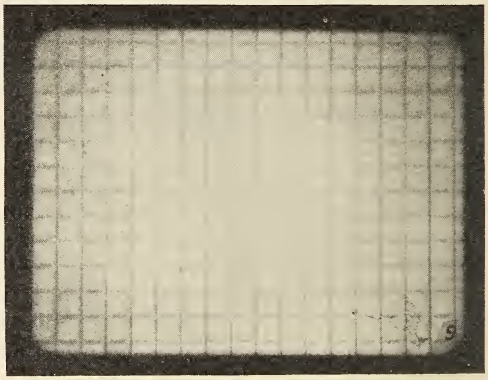


Fig. 9

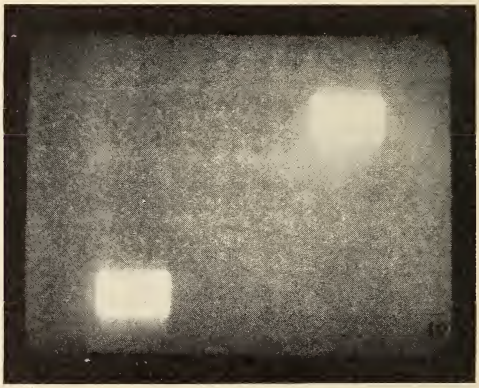


Fig. 10

Test No. 2.

Illustrations Nos. 7, 8, 9 and 10—This series of illustrations was made when using a shutter with semi-transparent celluloid blades, the cover blade being a dark amber and the flicker blade being a somewhat lighter shade of amber.

Illustration No. 7 shows the effect on the screen with the cover

blade stationary in the light ray. In this illustration the image of the line plate can still be seen. The definition, however, is very much damaged.

Illustration No. 8 shows the effect on the screen through the balance blade. In this illustration it will be noticed that the definition is very poor although the image of the line plate is very easily distinguished.

Fig. 11

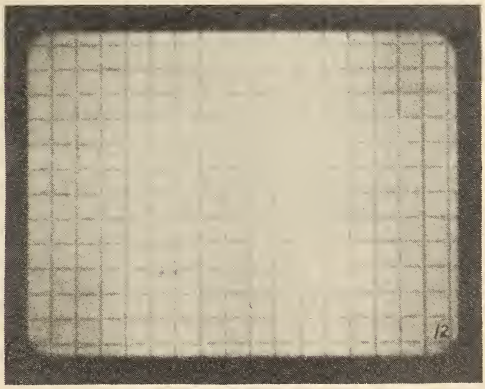


Fig. 12

Illustration No. 9 shows the effect on the screen with the shutter revolving with the openings between blades closed. This illustration shows plainly the quality of the image which is added to the screen picture when using a shutter of this type.

Illustration No. 10 shows the result on the screen when projecting a piece of test film with this shutter. This illustration shows the

screen image as projected under operating conditions using test film. Compare this illustration with illustration No. 2A and it will be very plainly seen that the image projected through the shutter blades as shown by illustration No. 9 has greatly damaged the quality of the screen picture. A slight amount of travel ghost can be seen above and below the image of the perforations in the test film.

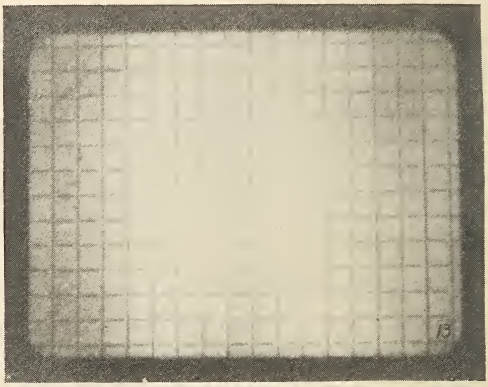


Fig. 13

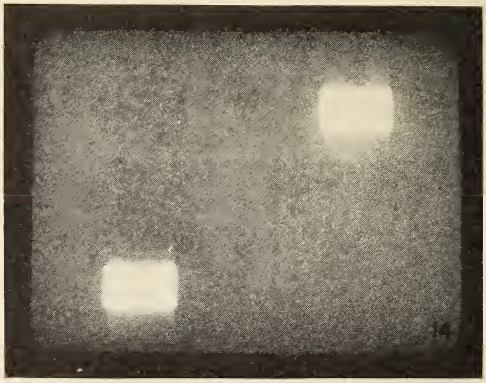


Fig. 14

Test No. 3.

Illustrations Nos. 11, 12, 13 and 14—This series of illustrations was made with a shutter having blades made up of two sheets of perforated metal, the cover blade having a thin sheet of translucent material inserted between the two perforated metal sheets.

Illustration No. 11 shows the effect on the screen through the cover blade. This illustration represents the effect on the screen image

when projecting through the cover blade. It will be noticed that the image of the line plate is almost entirely destroyed, and that the light is spread very unevenly over the surface of the screen; also, that the light extends considerably beyond the aperture line.

Illustration No. 12 shows the image of the line plate as projected through the balance blade. The lack of definition is very noticeable.

Illustration No. 13 shows the effect on the screen with the shutter revolving, having openings between blades closed. This illustration as No. 5 in Test No. 1 shows the quality of the screen image which is projected through the shutter blades, and it is evident that the addition of this image to the screen picture must result in damage to the definition.

Illustration No. 14 shows the result on the screen when projecting a piece of test film with this shutter. This illustration shows plainly the quality of screen image when projecting with this type of shutter.

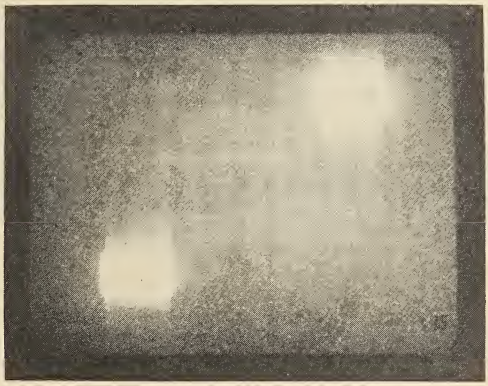


Fig. 15

The damage which is done to the screen picture is very noticeable if this illustration is compared with illustration 2A. Illustration No. 2A and this illustration No. 14 were photographed under identical conditions excepting that when photographing No. 2A an opaque shutter was used and when photographing No. 14 the shutter as described at the beginning of this test was used.

We have selected one other illustration No. 15— This shows the effect on the screen when projecting a piece of test film through a shutter made of thin celluloid blades, the cover blade being a very dark shade of blue, and the balance blade being composed of two sections, one orange-red and the other green. The lack of definition is very noticeable in this illustration and considerable travel ghost is also present above and below the image of the perforations in the test film.

From the results shown by these tests it is evident that the light which passes through the shutter blades certainly cannot improve

the appearance of the screen picture, and that it will more or less seriously damage the contrast between the lights and shadows. It is possible that the travel ghost which is noticeable in the pictures which were taken with test film can be eliminated by widening the cover blade and that the travel ghost remaining being out of focus would not be visible as travel ghost on the screen. By widening the cover blade, however, the light reaching the screen would be considerably reduced and there would be very little increase in illumination between these shutters and an opaque shutter.

Many of the shutters tested effected a considerable reduction in flicker and it is possible to project without noticeable flicker at lower speeds when using shutters of this type than is possible with an opaque shutter.

Regardless of the possible increase in illumination and the possibility of reducing noticeable flicker when using shutters which pass light through the blades, we believe these tests have shown that the quality of the screen image is materially damaged and that where the very best screen results are desired an opaque shutter should always be recommended.

DISCUSSION

MR. RICHARDSON: There are things to consider aside from those discussed in the paper, particularly with relation to the light from the high intensity arc. Many screens illuminated with that light source have a dead, chalky-white appearance. We have found it possible to tone this light, and to this end some projectionists are using what is known as the "Runcie" shutter, which is a rotating shutter with blades made up of slightly translucent colors, in carefully selected combination. The toning of the light renders it far more pleasing to the eye.

MR. GRIFFIN: The point of this paper was to bring out the effect on the screen picture when light is passed through the shutter blades. The best way to eliminate the chalkiness is not with the shutter but with a filter placed over the lens.

MR. DAVIDSON: Is not the trouble on the screen due to the material used in the shutter? The fact that the shutter shows an indistinct image might indicate that the material was not flat or had defects in it.

MR. BOWEN: As Mr. Davidson suspects, the lack of definition in the screen image is due to the material used in the shutter blades and it is certainly true that if the shutter blades were constructed of a plane parallel material, there would be at all times a sharply defined image on the screen whether projected through the shutter blades or not. If it were not for the fact that the cover blades of practically all of these shutters are purposely made of a material which will diffuse the light and thereby almost entirely destroy the screen image, the movement of the film would be very plainly seen as travel ghost on the screen. The diffusing quality of the cover blades can be reduced as we increase their opacity but it is not possible to use a cover blade which will pass a considerable amount of light unless it is constructed of some material which will destroy the screen image.

MR. KUNZMANN: Has Mr. Griffin made any tests with the double disk shutter to determine light increase over the shutters supplied with projectors?

MR. GRIFFIN: No, we didn't make any tests with it.

MR. ROEBUCK: Is it practical to produce the same results in a single system, such as a filter, as is produced with two different tints in the opposing wings of a shutter?

MR. RICHARDSON: Filters have not been found satisfactory.

MR. HILL: I should like to take this opportunity to say that there is another solution to the problem of "chalkiness" of the light from the high intensity arc. Dr. Kellner in his paper before the Roscoe convention (Results Obtained with the Relay Condensing System) pointed out that when using the high intensity arc with ordinary condensers, only the bluish light from the gas ball is util-

ized, the light from the reddish rim or shell of the crater being cut off by the film aperture. With a Relay or Tandem condensing system, light from both the gas ball and the shell is collected and evenly mixed at the film, so that we get a satisfactory color by additive synthesis.

MR. GRIFFIN: In reply to Mr. Hill, that is one of the things we are experimenting with. That is why I said it is possible to do it by other means than the shutter.

MR. RICHARDSON: That doesn't answer the question. It is not a single color but a combination of colors which is necessary to get the desired results. Very expensive experiments have been made with filters, and many theaters have adopted color in the rotating shutter of the projector as being more satisfactory. The Capitol Theater, in New York City, is one which has done so and there are many others.

MR. BOWEN: Mr. Richardson's present and former questions have to do with a phase of the shutter problem not mentioned in this paper. As Mr. Richardson points out, it is quite possible to secure some very pleasing effects with shutters having colored blades, but these effects are secured at the expense of definition in the screen picture, and I believe Mr. Richardson will agree that if there is a noticeable amount of light passing through the cover blade of a shutter which does not destroy the screen image, there would be very objectionable travel ghost.

It is equally certain that if the cover blade is made opaque enough to overcome this difficulty, the shutter would be unbalanced and cause excessive flicker due to the light passing through the flicker blade or blades. I can assure Mr. Richardson that any toning or color effect which is possible with the shutter can be secured in other ways just as successfully without sacrificing the definition of the screen picture. It seems that the only advantage in using any shutter of this type is the fact that it is possible to increase the screen illumination by its use.

THE USE OF MOTION PICTURES IN EDUCATION

By F. N. Freeman*

THE extensive use of motion pictures in the schools is a very recent development. Experiments on the production of motion pictures, having for their purpose to convey scientific information, were undertaken in the early stages of the industry. Since the invention of motion pictures, numerous attempts have been made to produce educational films on a large scale and introduce them into the schools. The use of motion pictures in the schools, however, has not by any means kept pace with their use in the theater. While theatrical motion pictures have grown until they constitute one of the most extensive forms of recreation of the American people, educational motion pictures are still on trial, and are used only to supplement, in a limited and irregular way, the usual forms of instruction.

A movement to introduce motion pictures into the schools on a larger scale has been in existence for the past few years. Some years ago a group of men who were interested in visual education formed an association called the National Academy of Visual Instruction. This society was composed largely of persons in charge of extension departments in the universities—men who were not directly responsible for the administration of school systems. More recently another association was formed which was named The Visual Instruction Association of America. This association includes both directors of visual instruction in school systems and representatives of the producers. Its purpose was to bring about a better coördination between producers and educators. More recently still the National Education Association has taken cognizance of the movement in the formation of a Department of Visual Instruction. The purpose of this department is to coördinate the various agencies in the field.

A somewhat different type of association was formed about four years ago. This association, the Society for Visual Education, is both an educational and a producing organization. It secured the coöperation of a number of educators, and of business men with capital, for the purpose of producing films which should meet the needs of the schools better than they had previously been met. This society published a journal entitled Visual Education. The field of educational journalism was further represented by a monthly magazine entitled The Moving Picture Age. These journals have been absorbed by the young and vigorously growing Educational Screen.

As final evidence of the current interest in the educational use of motion pictures may be mentioned the series of investigations of the subject which have recently been conducted. At least four

* University of Chicago, Chicago, Ill.

candidates for the doctor's degree in education, J. J. Weber, Roy L. Davis, F. D. McClusky and C. E. Skinner, conducted studies in visual education for their dissertations. A grant was made two years ago by the Commonwealth Fund of New York to the University of Chicago for the investigation of the effectiveness of motion pictures as instruments for teaching. The report of this investigation was published by the University of Chicago Press under the title, Visual Education. Last year The Motion Picture Producers and Distributors of America supported a survey of the existing practices in the field, which was made under the auspices of the National Education Association. The report of this survey will probably be published in the near future.

With these evidences of the current interest in the use of motion pictures in the school before us let us review briefly the actual situation with regard to such use. This review will show that there are several problems to be solved and obstacles to be overcome before the demand for the introduction of motion pictures which is represented by the associations and journals and investigations already mentioned can be met. These problems are partly of an administrative and material nature and partly of psychological nature. They concern such matters as the production and distribution of films suitable to the school, and the question as to just what the instructional value of motion pictures is and what kind of motion pictures possess this value. The existence of these problems, which are not yet completely solved, has made the advance of educational motion pictures a somewhat halting one.

Let us first glance at the administrative situation and at the problems which it presents. An essential characteristic of the use of motion pictures in the schools at the present time is that it involves a centralized organization. Motion picture films are not stored in the individual classrooms or even in the individual schools, but they are kept in a central vault in a central building from which they are distributed. The center of distribution sometimes serves a city and sometimes a state or even a larger area. In some cases projectors are likewise kept in a central depository, while in some cases they are the property of individual schools or belong in individual schools or rooms.

Few, if any, other types of educational material are so universally centralized as are motion picture films. Models, stuffed birds and animals, specimens of agricultural or manufactured products, and similar materials, are sometimes kept in a central museum and sometimes in the school buildings. Maps, pictures and the like are usually duplicated and kept in buildings or classrooms. Slides and stereographs may be centralized or de-centralized. Textbooks are never kept in a central depository and reference books and books for supplementary reading are usually kept in a library in the individual school. Laboratory apparatus is always kept in the school building.

The centralization of motion picture films is due in part to the necessity of keeping them in a storage vault, to the care they require

in order to be kept in good condition, to their expensiveness, to the fact that it requires an officer with special training to select and procure them and to promote their use, and perhaps to their comparative newness. But whatever the causes, this fact has important consequences for the use of films in the schools.

It is obvious that the centralization of motion picture films creates the problem of their distribution. This is true of both types of centralization, whether in state universities or state departments of education or in city departments. If a bit of material is in a central office it is not as readily available to the teacher as though it were in her own classroom or in the same building. It becomes necessary that some system be put into operation to make the material as easily available as possible.

There are, in general, two forms of distribution in use, the special order method and the circuit method. According to the special order method the teacher anticipates his need for a certain bit of material a certain time in advance, varying according to the practice of the department, and secures it by special messenger, or by some form of regular delivery system. The advantage of this method is that the teacher secures the material for which he recognizes a need and which will therefore contribute vitally to his presentation of the subject. The disadvantage is that the necessity of planning ahead constitutes an inhibition which reduces the use of the material and makes it impossible to use it to fill needs as they may arise in spontaneous discussion. A further disadvantage is that the teacher may not know enough about the available material to take full advantage of it.

The circuit method furnishes the teacher with material without the necessity of his planning ahead to order it, but it exaggerates the difficulty of fitting the material into the subject matter of instruction. It makes it almost necessary to treat the motion picture film as a separate, unrelated unit. The method relieves the teacher of the labor of searching for material to illuminate and make concrete his instruction, but this very relief is likely to absolve him of the necessity of giving sufficient study to the relationship between the visual material and the ideas which he is undertaking to make clear in his teaching.

We see then that the centralization of motion picture films seems to be dictated by the nature of the material, but that centralization creates certain problems in the use of films which have not been solved with entire success by either of the two methods of distribution. This limited success in distribution is probably responsible, in part, for our failure to realize fully the possibilities of the use of motion pictures in the schools.

Another problem which confronts the educator is how to secure the films. Two procedures are open to him. He may either buy the films or he may rent them. Both methods are followed. Each has its advantages. If the films are bought they are available for use at any time and can be secured by teachers with maximum certainty

and speed. On the other hand, renting films relieves the school of the care and storage of the films and prevents the accumulation of old and obsolete films. It is uncertain which method is more economical in the long run.

The divergences in practice extend also to the character of the films in use. The most distinctive service of motion pictures in education probably lies in the use of films which are factual in character—which give the pupils a direct acquaintance with things and with their actions which he would have difficulty in securing in any other way. It is perhaps surprising, then, to find that the type of films which prevail in the school are for entertainment. They are the dramatic, narrative films such as are shown in the theater. In fact many, if not most of them, are the actual films which are produced for the theater and first screened there. One survey indicates that eighty percent of the films in the school are entertainment films.

Probably one chief reason for the extensive use of entertainment films is their greater abundance, due to the fact that they have a wider and steadier market than the school. Another reason is the relatively unsatisfactory character of many of the informational films and the fact that they have not yet been developed so as to meet the peculiar needs of the school. We shall recur to this point again. A third reason is that an informational film, to be of greatest use, should fit precisely into the place in the course of study where it is needed. We have already seen that the method of distribution makes this difficult.

Still another divergence in procedure brings out further the lack of standardization of the use of motion pictures. It is the practice in some schools to show the films in the auditorium. This frequently involves grouping several calsses of pupils for the same showing. It requires the selection of films which are suited to pupils of a rather wide range of maturity, interests and preparation. It makes it impossible to select films on the ground of their adaptation to the topic which is being studied by a particular class at a particular time. The contrasted practice is to show the films in the classroom. In this case a portable projector has to be used. This permits closer correlation with class work, provided the film can be secured when it is needed. Projection in the classroom is out of the question in some places on account of the fire regulations.

It is clear from the foregoing description of the current practices that the advance in the use of motion pictures in the schools depends in part upon certain conditions which are entirely external to the value of the motion pictures themselves. If motion pictures prove to have sufficient value the difficulties which have been mentioned can probably be overcome. But there is a disposition to proceed cautiously and experimentally in the extension of visual education in order that the best methods may be discovered. In particular, the problem of fitting the motion picture into the work of the class—what may be called correlation—demands especial study. This is perhaps

the weakest point in the present procedure. It concerns the character of the films themselves, their distribution, and the method of projecting them.

It is probable that the showing of motion picture films could be more closely interwoven into the instruction of the classroom if the character of the films was somewhat modified. Their form has been partly determined by the theater tradition. They come mainly, for example, in rather large and uniform units. It might frequently be desirable to exhibit much smaller units than the thousand foot reel to illustrate a particular point under discussion. This would be made much easier if the projector could be modified so as to facilitate threading and rewinding. The units could be shortened further if we could abandon or modify the theater tradition of making each film entirely self-explanatory by means of subtitles. It might often be desirable to present a picture to a class for study instead of attempting to explain it. This might make it desirable to repeat the film or part of it. Experiments have shown that oral comment by the teacher, if properly made, is more effective than printed subtitles. There is undoubtedly room for the development of films so as to make them better adapted to classroom use.

We have been considering the material and administrative aspects of the problem. We may turn to the psychological question: What can motion pictures probably contribute to education? In attempting to answer this question it may be well at the outset to deal with certain exaggerated and unwarranted claims which have been made. It is frequently asserted that motion pictures and other forms of visual education are of paramount importance because sensations of sight far outstrip all other kinds of sensations as means of acquiring an experience of the material world. Eighty-seven per cent of our experience, we are told, is gained through the sense of sight, and vision should be used in a corresponding proportion as an avenue of instruction.

In so far as such an estimate can be subjected to experimental investigation it is found to be untrue. A fundamental objection to it, moreover, is that nearly all of our experience is composite. It does not rest upon any one kind of sensation but upon a combination of several. Psychologists know this and never indulge in such comparisons. They are the product of the uncritical thinking of laymen.

The question of the value or the superiority of motion pictures as means of instruction cannot be answered in a wholesale fashion, nor on the basis of general theory merely. It must be answered in detail and on the basis of careful experimental study. A variety of circumstances affect their value. They are more suitable for some subjects or some topics than for others. Their importance—and the importance of object teaching in general—depends in part on the amount of contact the pupils have previously had with the things which are the subject of instruction. The mental type of the learner may possibly be a factor to be considered.

It may perhaps seem unnecessary to point out another circumstance that affects the comparison between motion pictures and other methods of presentation, such as the textbook, the illustrated lecture, the slide or the stereograph. This circumstance is the quality of the film and the adaptation of the subject to this type of presentation. It seems absurd to conclude that because a good motion picture may possess superior effectiveness a poor one will also, or because a film is a superior means of presenting one subject it is a superior means of presenting all other subjects. Such conclusions are often drawn, but their absurdity is evident on the face of them.

The diversity in the value of films may be illustrated by an example drawn from an experimental study of two films. The effectiveness of the two films was measured by showing each of them to a number of classes of pupils and by teaching the same lesson to other classes similar to the first in age, ability and training, by some other method. The amount which the pupils learned from this picture was then compared with the amount the other pupils learned from the other method of presentation by giving both groups the same test.

One of the films was designed to teach certain facts of early American history. It was produced by an excellent company with the coöperation of specialists in education. It was compared with an oral lecture, illustrated by maps. The illustrated oral lecture proved repeatedly to be decidedly the better of the two. The second film was in the field of physiology. It showed the structure and action of the human eye. This film was compared with an oral lecture. It proved to be very superior to the lecture. Undoubtedly the oral lecture would have been more effective if it had been illustrated, but there were other cases in which the lecture without illustration gave as good results as the film. Many other examples could be cited to further verify the statement that some educational films are successful and others are not.

Our experimental evidence is still too meager to indicate completely and in detail just what subjects and topics can best be taught with the aid of motion pictures, and just what sort of motion pictures will serve their purpose best. Our experiments suggest in broad outline the types of subjects which can best be illustrated by motion pictures, however, and we may venture to list some of the more important.

Motion pictures may be used to advantage in presenting certain forms of scenic views. There is no point in showing motionless objects with the motion picture, as is sometimes done. But motion may be used effectively in several ways. Moving objects enliven a landscape and give it an appearance of reality. Objects coming toward or receding from the camera may intensify the perspective. If the camera is moved about an object it aids the observer in comprehending the relationship of its various parts and aspects.

More important is the application of motion pictures to show processes. Experiments indicate that the motion picture is not superior, and probably not equal to a direct view of the process itself. But when such direct view is not available, the motion picture forms an excellent substitute. Many excellent motion pictures have been produced which show processes of manufacture or the occupational activities of people in various parts of the world. Pictures of this sort are sometimes lacking in completeness, consecutiveness or detail, but on the whole they constitute an important addition to our educational materials.

The next step beyond showing a process as a whole is the analysis of an activity, or the synthesis of an activity. Synthesis occurs when the action in its natural form is so slow that it cannot be perceived. Speeded up pictures have been used to show actions, as the unfolding of a flower. This type of picture has been employed more as a novelty than as a means of serious study. It probably has unrealized possibilities. Slowed down motion pictures have served to analyze motion. They are useful in teaching the performance of acts of skill. They may be used to illustrate the manner of performing a single act, such as throwing a base-ball, or of performing a series of acts, as weaving a reed mat.

Another type of anlysis is made by means of the animated diagram. Animated diagrams bear the same relation to pictures of moving objects as ordinary diagrams bear to pictures of still objects. They divest the object of those aspects which are not essential to an understanding of a certain type of relationship. In ordinary drawings the aim is chiefly to show structural relationship, while in animated drawings the aim is to show functional relationships. Such drawings have proved serviceable in making plain the action of machines or the performance of physiological functions.

Besides these special types of analysis, motion pictures serve to make wide acquaintance possible with the demonstration of scientific laws by means of expensive and unusual laboratory apparatus, with the behavior of animals which are very difficult of access and with acts requiring unusual skill or an especially favorable viewpoint. These types are illustrated respectively by a film on the life history of a butterfly, by one showing the demonstration of elaborate apparatus in the science of physics and by films exhibiting intricate forms of surgery.

It will be seen from these illustrations that motion pictures have a distinctive and important function. They serve certain purposes particularly well. Their function is complementary to other modes of teaching, however, and cannot successfully supplant either other means of giving concrete experience, on the one hand, or the more abstract form of instruction, on the other hand. Still pictures, models, laboratory apparatus, slides, etc., have distinct functions, and in their own field they are not only cheaper but are more effective than motion pictures. Motion pictures will be successful in proportion as they cultivate their own distinctive field.

The possibilities of motion pictures in education are great. The realization of these possibilities will be hastened through technical improvements which will make motion pictures cheaper, more durable and more easily moulded to the purposes of the teacher, and by a clear recognition of the distinctive mission of motion pictures and an abandonment of the attempt to cultivate fields belonging to other modes of instruction. Motion pictures are not a universal mode of instruction but they are a highly valuable special form of instruction.

DISCUSSION

MR. FRITTS: Of what value do you consider the ability to project stills with the average equipment?

MR. FREEMAN: It would make the use of the motion picture more flexible and in general is an advantage if it can be done. If one can switch readily from one to the other and have motion pictures in small units to show a particular aspect of a motion and then switch back to show another aspect, it would add to the flexibility and the usefulness.

MR. PECK: I should like to ask Mr. Freeman his opinion of films such as travelogues; what is the reception given by the scholars to this type of film?

MR. FREEMAN: I think that is one of the types which is desirable; it may be termed "descriptive geography," bringing the child to acquaintance with what he would see in traveling.

MR. RICHARDSON: It seems to me the present ability to stop the film with the light from the source commonly used would serve the purpose Mr. Freeman has named, but what I think Mr. Freeman meant was the motion picture projector with a stereopticon attachment so that motion pictures and slides may be projected with the same projector.

MR. FREEMAN: I had in mind both types. The type in which you can stop the film itself and possibly analyze the particular picture and the other in which you can switch to a still picture to compare it with the film. I think both types are worth while because it may be desirable to use other materials than are contained in the films.

MR. BRIEFER: What work has been done to discover the reasons for the difference between effective and non-effective educational motion pictures? Undoubtedly the answer is to be found in the psychological attitude of the student to the form of study—psychological differences in degrees of imagination. Some students, having a high degree of imagination, will follow the portrayed events composing the study and assemble them to form a complete and logical mental picture. Others, not so well equipped mentally, will be attracted from one detail to another, lacking ability to relate the separate or component parts. It may be that those responsible for preparing educational motion pictures weave into them a kind of story in the hope of making them attractive and so innocently detract from the primary object of the work. The effect of pictures, relative to the psychology of the student, is the factor requiring considerable study. Until we carefully explore the student mind and its attitude toward educational motion pictures, experimentally developing suitable forms and methods of use, their application to study will fail to meet expectations.

Mr. Freeman: I think I can answer that, at least in part, by explaining the character of the film. It was not a dramatic film, as are many of our historical pictures. It contained much the same kind of information that a teacher attempts to give by discussion with a motion picture. The subject of the film was French explorations which showed a number of maps containing an animated line. The purpose was to teach the pupils the course of the travel of those men. Now, the teacher attempted to do the same thing by having a map constantly before the pupils and pointed out the course of the travels. It appeared that in this way, the result was more effective than a man with an animated line disappearing and having something else shown.

Mr. Briefer: It is possible that an animated map would not be as effective as the teacher's description with a pointer. My impression was that historical events were shown.

Mr. Freeman: No.

Mr. Ricker: May I call attention to one factor in the fairness of a test of that kind—the attitude of the child toward the lesson is a very vital thing. It is not a fair test to take a picture into a classroom where the children have been taught by teachers and from textbooks and then test the adaptability of the child to gain information from the map as against the text-book with, back of it, a lifetime experience in teaching children. I have observed that in motion pictures to be used here and there, the attitude is that there is "going to be an entertainment" which kills the idea of the whole thing.

Mr. Richardson: Schools are gradually working into new fields, and I notice in the papers there is going to be a time set apart in our large schools to teach children safety in traffic which I don't think would be taken care of so well in any other way.

Mr. Griffin: As an indication of the interest that motion pictures are creating in the educational system of New York City, there are nineteen new schools being built which have included in their budget motion picture education.

President Jones: On behalf of the Society, I want to express our thanks to Mr. Freeman for coming here and giving us this paper. We are vitally interested in this subject, and we are very glad to get the view of the educator on the motion picture. I think we need the advice of the real experts in this field; we expect to be consulted on matters of motion picture engineering and think an individual is foolish to go ahead and work in our field without consulting the motion picture engineer, and I think we in turn must go to the educator to get his information.

PRACTICAL TESTS OF CINEMATOGRAPHIC LENSES

By Edwin C. Fritts

THE purpose of this paper is to suggest to the practical motion picture photographer tests which he might apply to the objectives of his equipment. For the most part, the following material on taking lenses is furnished by Dr. F. M. Bishop, while that on projection lenses is taken from a paper by Dr. G. W. Moffitt.*

Taking Lenses

As a basis for our tests on taking objectives, we will use, with slight modification, the methods which have been used in still camera lenses. These must be modified slightly because of the short focal length of motion picture lenses and the corresponding size of the image.

Before a given lens is tested, the camera in which it is used should be carefully inspected to see that no mechanical faults occur to confuse the results, such as misalignment of lens and aperture, and defects which might cause the film to vary in its position. The lens itself should be inspected for cleanliness and mechanical faults.

Special care should be followed in cleaning the lens. Lens cloths should be washed several times without starching to avoid the possibility of scratching. A clean, linen pocket handkerchief may be used but any perspiration present in the handkerchief will leave a film of oil on the lens which forms a new lens surface and introduces errors in the lens operation. For the same reason the lens should not be touched with the fingers. Special lens paper may be procured in book form.

To make the tests which will be mentioned below, resolves itself into photographing such subjects as will best show the defects in mind. In making the tests it is wise to photograph the subject at different settings, about the point of critical focus. Starting with the lens set so that the image is distinctly out of focus, expose a few frames and then pass a frame or two through the gate unexposed so as to separate this exposure from those which follow. Move the lens by a few thousandths of an inch toward the point of critical focus and again run a few frames. Continue in this way until the region is reached where the definition is lost on the other side of the point of critical focus. Be careful to crank at as nearly the same speed in each exposure as possible. It will be wise to run sufficient film each time to get the machine to a normal cranking speed. Develop the exposures in one strip so as to assure equal development, and examine them with a good magnifying glass rather than by projection,

* Moffitt, G. W., Jour. Opt. Soc., Nov., 1922, p. 940.

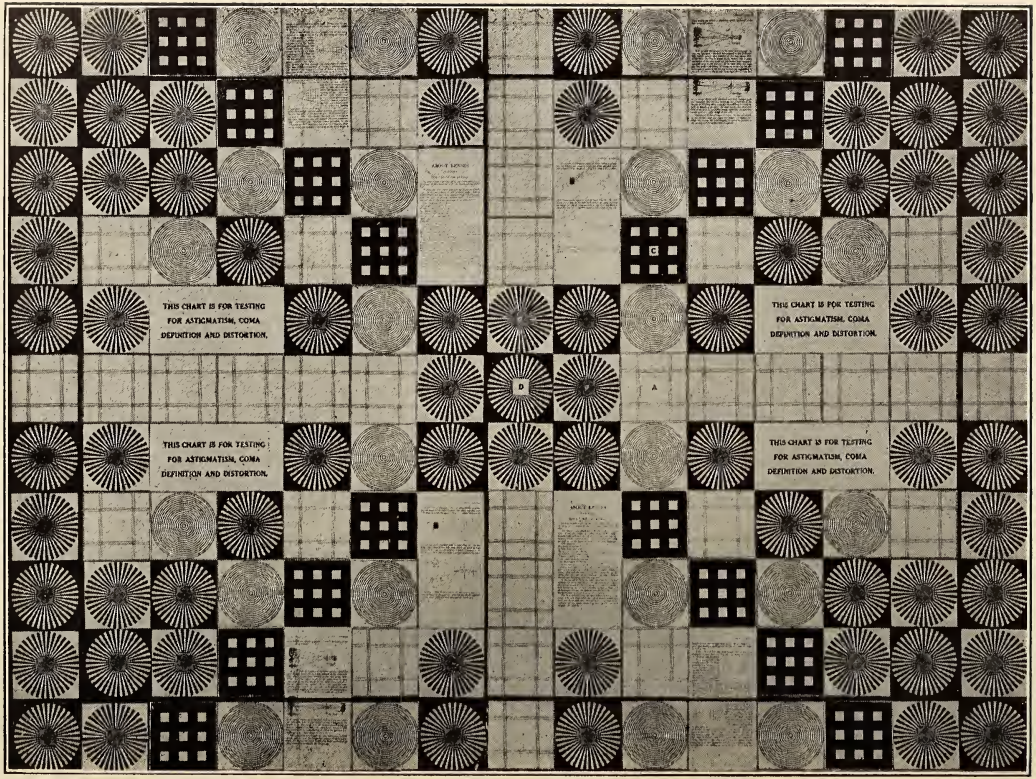


Figure 1. Practical Tests of Cinematographic Lenses.

to eliminate errors which might occur in the projector and which would confuse the results.

Figure 1 is a proposed lens chart which may be used in making the following tests: In using it a suitable distance should be chosen so that the chart just fills the aperture in which case the elements are best located for the test. The elements marked A are primarily to test for astigmatism. Elements C are used to test for coma, while elements D, so-called "pie-charts" are for general definition.

In Figure 1 the detail of the elements D has been somewhat lost by reproduction. The black sectors extend in to the center and when photographed the size of the central region of these chart elements in which resolution is lost is a measure of the lack of definition in the lens. If this region is shaped like a figure eight rather than a circle, it is an indication of astigmatism. When discussing the use of the lens chart below, it will be assumed that exposures have been made as suggested above.

Astigmatism

Elements A of the lens chart are composed of two sets of narrow rulings at right angles to each other (not shown clearly in the halftone cut).

Since the effect of astigmatism is to reproduce points in the object plane as radial and tangential lines on slightly different image planes, one set of rulings will appear in sharp focus while the set at right angles to it will be out of focus. In general the center of the exposure area will appear sharp and the astigmatism will reach a maximum at a point about half the average covering power of the lens and then decrease with increasing angle of field.

Astigmatism is also shown on the concentric circle elements by bringing the parts of these circles into focus which are located along radial lines about the lens axis as a center, while the tangential portions are out of focus and vice versa.

Field Curvature

Curvature of field will be shown by an examination of exposures made on successive lens settings. At the point of critical focus, the center of the exposure area will appear sharp while in successive settings the region of best definition will be located on circles of increasing diameter. In choosing a lens for pictorial work, a slightly inward curving field is not always a disadvantage since it tends to bring the foreground in focus. For this test, it is well to choose a subject which lies all in the same plane at right angles to the axis of the lens. The lens chart or a distant scene will serve this purpose.

Chromatic Aberration

Since chromatic aberration is defined as different focal lengths for different colored lights, its presence in a lens to any very large extent can be detected by an examination of a white light source against a black background in which case the image will be sur-

rounded by color fringes, red on one side and blue on the other. The filament of a tungsten lamp will serve as a good subject for this purpose. The photographic tests mentioned above will not conclusively distinguish between chromatic and spherical aberration but will show the presence of either by lack of a point of critically sharp definition.

Spherical Aberration

Since spherical aberration is defined as different focal lengths for different annular regions of the lens, it will be impossible to find a setting which will give critical definition when the lens is used at full aperture if spherical aberration is present. With the method of testing outlined above, several successive lens settings will give the same degree of central definition, none of which is critically sharp.

Coma

When the images formed by rays passing obliquely through different annular portions of a lens are brought to slightly different focal points this special case of spherical aberration is known as "coma." In practice the image of a point on the object plane will appear with a radial tail resembling a comet. This tail may point either toward or away from the axis of the lens. Its effect will be noted on the test chart by blocking up the corners of the small squares. Another test for coma would be to photograph strong point sources of light such as street lights at night and note whether the images off the axis of the lens are sharp points or have cometic tails.

Flare and Flare Spots

A certain amount of light is always reflected by the lens surfaces and some of this reflected light may reach the film. In case the lens is so designed that this light will be focused near the focal plane the fog caused by it will be localized and will produce what is known as a "flare spot." If the reflected light is focused near the lens itself, it will be diffused over the aperture as a whole and the effect will be a general loss in contrast. To test for flare, photograph a scene composed of about equal portions of sky and shadow exposing for the shadows. If this image has a distinctly flatter appearance than the same subject photographed from a position to eliminate the sky, the degree of flatness is a measure of flare. A general idea of the position of the images formed by reflected light will be obtained by looking through the lens toward but not directly at a strong source of light keeping the eye near the axis of the lens and focused on the lens itself.

Distortion

Distortion may easily be detected in a lens by photographing rectangular lines along the margin of the exposure area. A straight edge placed against the image of this line will determine whether or or not the lens is strictly rectilinear. A brick wall will serve very well as a subject for this purpose. On the lens chart suggested above, the black lines bordering the chart are to be used for tests of distortion.

Illumination

Tests for uniformity of illumination may be made by photographing a uniformly illuminated subject such as a clear sky. In most cases the angle covered by cine lenses is small, so that the lens barrel does not cut off an appreciable amount of illumination from the edge of the field.

The success with which the above tests can be applied will vary. We feel that those outlined are about as simple as any which can be made by the practical photographer. A comparison of different lenses will often be necessary and their relative merits judged by the standards outlined rather than to attempt absolute measurements of one lens alone.

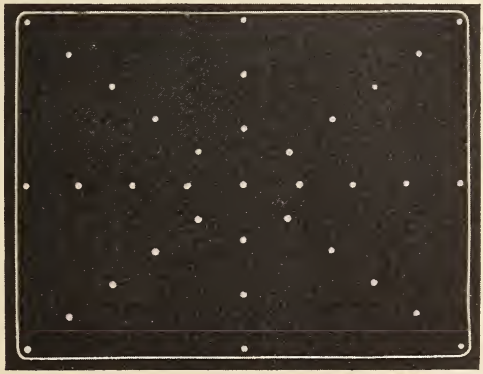


Fig. 2. Practical Tests on Cinematographic Lenses

Projection Lenses

Projection lenses cannot be tested in any manner similar to any other type of lens. They are a particular problem in themselves and must be treated as such. For the most part, the difference between taking and projection lenses under test lies in the uneven zonal illumination in the latter case. We should test a projection lens for definition, quality and illumination characteristics.

For reason mentioned above a projection lens should be tested under actual throw conditions. Mechanical faults in the projector which might alter the conditions should be carefully watched and due allowance made.

Definition

In the tests of definition the projector should be at rest since we are considering the optical characteristics of the lens alone. To do this it will be necessary to use in place of the film a metallic aperture plate which is rigid enough to stand the temperature. It should be very

flat and it is well to make it in such a manner that it may be reversed in the aperture in as many ways as possible. This will enable one to distinguish between errors in the plate and those in the lens itself. Figure 2 shows such a plate.

The image of this plate should be focused slightly in front of the screen and a small piece of white cardboard used to explore and study the relation of the images to a given focal place. In Figure 2 it will be noted that three holes are placed in the same straight line along each side of the aperture plate. These should appear in line on the screen if the lens is free from distortion. In such a test astigmatism will be noted by the occurrence of two distinct positions of best definition for the holes. These will be found at different distances from the screen and will be slightly elongated along diameters at right angles to each other. If chromatic aberration is present, each image will be surrounded by color fringes. These should not be confused with the color fringes over the field as a whole owing to poor adjustment of the condenser system. If the images fall on a saucer shaped surface, this is an indication of field curvature. Coma, when present, will produce the characteristic comet shaped image. A general condition of poor definition will result from spherical aberration.

Quality

The quality of the lens will be determined by the amount of flare and generally diffused light reaching the screen. The aperture plate may also be used in tests for flare. Flare spots will produce regions of local illumination between the images of the holes. General flare will produce a more or less uniform illumination over the entire field. Definite measurement of flare involves the use of photometric apparatus.

Illumination

It is difficult for the projectionist actually to measure the illumination characteristics of the lens since this involves the use of a photometer. However, any lens which will give satisfactory visual illumination when a clear aperture is used will be satisfactory when film is projected. It is not wise to judge a lens on the basis of screen brightness unless due allowance is made for the irregularities of the screen. If the projector is moved, it is obvious that any lack of uniformity caused by the screen will remain stationary while faults of lens illumination will move with the beam.

It is hoped that the material of this paper may enable the camera man and the projectionist to arrive at a more definite idea of the characteristics of their lens equipment.

Development Department.
Eastman Kodak Company
Rochester, N. Y.
December, 1924.

DISCUSSION

Mr. Fritts: I am going to try to have prepared before I hand this paper over for publication a lens chart which will be a full plate in the Proceedings and which may be available to a photgrapher at his desk.

Mr. Roebuck: Was anything said against the use of a pocket handkerchief for cleaning the lens and advising what we should use?

Several speakers followed suggesting clean chamois skin, lens paper, a well washed linen pocket handkerchief, etc.

President Jones: I might suggest at this point that silk is not good for cleaning a lens. It might be well to tell them what not to use. Well washed linen is satisfactory. New cloth as purchased is not good, and a pocket handkerchief of linen or cotton washed many times is about as good as can be obtained. Perhaps a general statement that cotton or linen fabric which has been thoroughly washed and dried without starch is all that is essential.

I take it that the result of this discussion is a suggestion that the author should add a note as to what should be used for cleaning a lens.

A NEW UNIT FOR PROFESSIONAL PROJECTION WITH TUNGSTEN FILAMENT LAMPS

"Communication No. 1 from the Research Laboratory of the U. S. Army Motion Picture Service."

Roger M. Hill

THE "Research Laboratory" referred to above consists of 105 theaters in the Posts and Stations of the Army, presenting the widest variety of projection problems ever assembled under one management. When the U. S. Army Motion Picture Service was organized for the purpose of operating these theaters on a centralized and businesslike basis, it became the task of that service to solve these varied problems. The unit which I am about to describe to you is one of the things which had to be developed before these problems could be solved. This unit is now in use in practically every Post and Station of the Army in the continental United States and Panama. Altho many are equipped with earlier types than the one here illustrated, the basic principles are the same.

Early in the history of incandescent lamp projection, this form of light source was brought to our attention. We immediately recognized some of its inherent advantages, such as cleanliness, steadiness of the light, freedom from heat and fumes and economy of operation. We accordingly began some extensive tests of the apparatus which had been developed for these lamps. These tests were of course conducted under theater conditions, and included the fitting up of one entire army corps area with the type of unit which proved most acceptable in the preliminary tests. I will not go into details here as to the results of these tests, except to say that the outcome was a decision to try our hand at the design and construction of a unit of our own. The mere fact that the tungsten filament lamp had survived the apparatus that had so far been designed for it was enough to convince us of its inherent merit.

We had by that time acquired some very definite notions as to what was desirable practice in design, and here are some of the points we decided upon:

1. ACCOMMODATION FOR LAMPS. Standard 30 ampere 900 watt mazda C Motion Picture Lamp will be used as the basis of design, but the equipment must be so constructed as to be adaptable to lamps taking up to 150 amperes, with standard, mogul, or special base: light centers from 2 to 7 inches, overall lengths to 15 inches.

2. ACCOMMODATION FOR CONDENSERS. Unit must be adaptable to all types of condensers: the condensers to be mounted on the interior of the housing upon a rigid support integral with the base of the unit.

3. REPLACEMENT OF LAMPS. Lamp sockets to be interchangeable, and removable from the unit by a single operation: sockets to be without connecting wires or SLIDING CONTACTS.

4. ADJUSTMENTS FOR LAMP AND REFLECTOR. 'Provision must be made so that the six necessary adjustments of the lamp and reflector may be made from the outside of the lamphouse, with the door closed and the lamp burning.

(A). The three adjustments of the lamp to be effected independently of each other: that is, the lamp to be raised or lowered without disturbing its position along the optical axis or across it, etc.

(B). The three adjustments of the reflector should be likewise independently effected.

(C). The lamp adjustments should also actuate the reflector, so that once set, the reflector will remain so, even tho the lamp is subsequently readjusted.

5. SETTING OF LAMP AND REFLECTOR. Lamp and reflector to be set by observation of a magnified image, projected by the condenser, upon a target.

That seems a pretty tough schedule, but we followed it most of the way even in our earliest models, and have carried it out entirely in our present model. The 900 Watt lamp is the one we are primarily concerned with at present, so I will not take time here to go into the method of adapting the unit to various lamps, other than to say that it can be made to cover the range outlined under No. 1 above. In condensers we have pretty definitely settled on two principal types: a 4½ inch diameter plano convex combination which is at present the standard for our smaller theaters, and a special condensing system used in the larger theaters, which will be described later. The present model unit is therefore made applicable to both of these types. I do not feel that it is necessary to comment here on the desirability of mounting the condenser on a rigid support integral with the base of the unit, rather than attaching it to a sheet metal lamphouse.

In the design of the lamp socket and mounting, we come to the first place where any real heavy thinking was necessary. When we undertook to get away from sliding contact arrangements, we took quite a lot upon ourselves. However, we now feel well repaid for the efforts that were necessary. Figure 1 shows the lamp socket and mounting, together with the adjusting mechanism of the unit. The socket consists of the usual threaded sleeve, which is attached to a disc of insulating material. Thru the center of this disc extends a post which forms the center contact of the socket. The mounting for this socket is an arm, insulated from the adjusting mechanism, and having a slot to receive the post on the lamp socket, and a locking device with insulated handle, which clamps the post tightly into the slot, at the same time seating the socket firmly down against the top of the arm. One lead wire is connected to the arm, the other to a resilient brush bearing against the threaded sleeve of the socket, and completing the circuit thru the lamp. To replace a lamp it is only necessary to give the locking handle a quarter turn, after which the lamp and socket can be lifted out and a new one substituted.

This arrangement has also proven convenient where the pro-

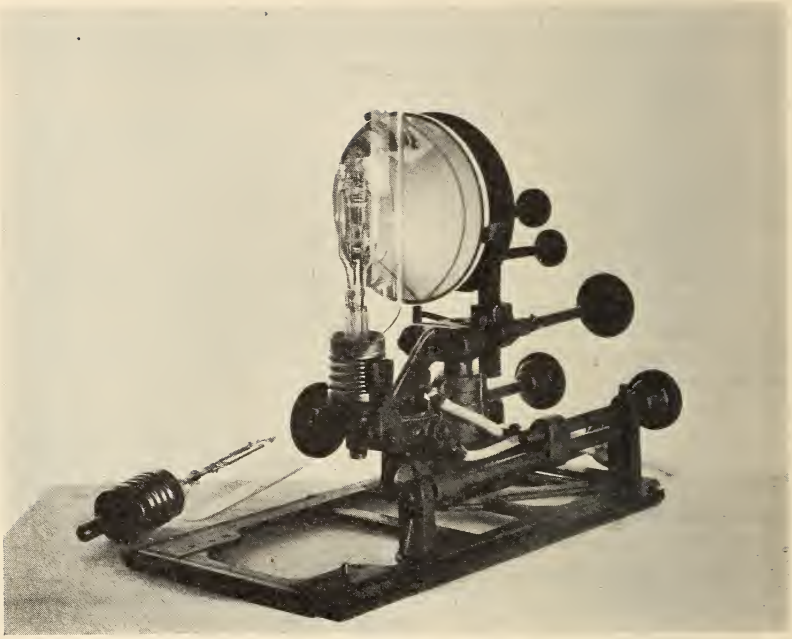


Fig. 1

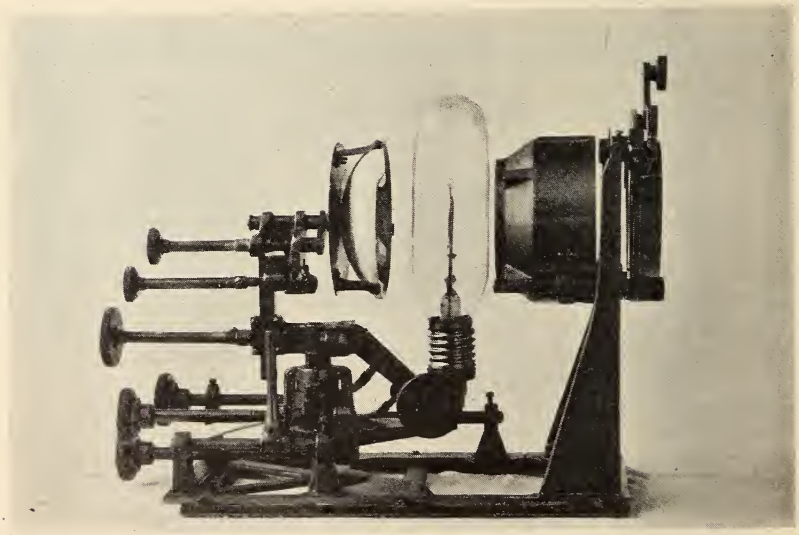


Fig. 2

jector is operating at a considerable angle, in which case it is necessary to frequently reverse the lamp to compensate for the sagging forward of the filament due to operating the lamp in an inclined position. The locking handle can be released, and the lamp and socket turned around without removal from the mounting.

The adjusting mechanism is illustrated more clearly in figure 2. The base of the fixture is a triangular shaped carriage, sliding laterally on guide rods integral with the base of the unit. Correct alignment in all positions is insured by the long separation between the bearings on the long rod at the left of the unit, while the short rod at the right does not interfere with the accessibility of the lamp and locking device. The carriage is actuated by a screw- and- nut movement, similar to those used in arc lamp structures.

Upon this triangular carriage is a turret which carries the lamp socket arm and reflector mechanism. This turret is elevated or lowered by a screw and nut in the center, actuated thru a spiral gear by a handle extending out from the rear of the carriage. The turret swings on its center to afford movement of the lamp across the optical axis. This adjustment is so clearly pictured as to require no description. A small spring controls the play in this adjustment, and at at the same time prevents any side movement of the lamp which might be caused by friction in the screw- and- nut elevating device.

You will note that the reflector is also actuated by these adjustments, and so always retains its position with respect to the lamp.

For adjusting the reflector with respect to the lamp, there are three additional movements provided. Vertical movement is by a rack and pinion. This is made purposely rather fast moving, for with a properly made reflector the reflected image is so much like the image of the filament itself as to cause confusion between them even to the eye of an experienced projectionist. The vertical movement of the reflector is therefore made so that a good twist of the handle throws the reflector well out of range. Another in the opposite direction of course brings it right back where it came from. A large handle is provided so that the final position of the reflector may be obtained with the desired precision. At the top of the rack rod is mounted a sub-bracket which is rotated to position the reflector across the optical axis: this sub-bracket in turn carries the reflector holder proper, which is moved along the optical axis by a screw- and- nut focusing device. The reflector is supported by two rigid arms and a flat spring arm.

The base adjusting handles require no universal joints, as they remain always parallel to the base of the fixture. The reflector adjusting handles of course travel, but an opening in the rear of the lamphouse sufficient for this travel is not objectionable, as the reflector cuts off both the direct rays from the lamp and those reflected from the rear face of the condenser.

Figure 3 illustrates the manner in which the condensers are accommodated. These are mounted in a jacket, which rests upon two rods

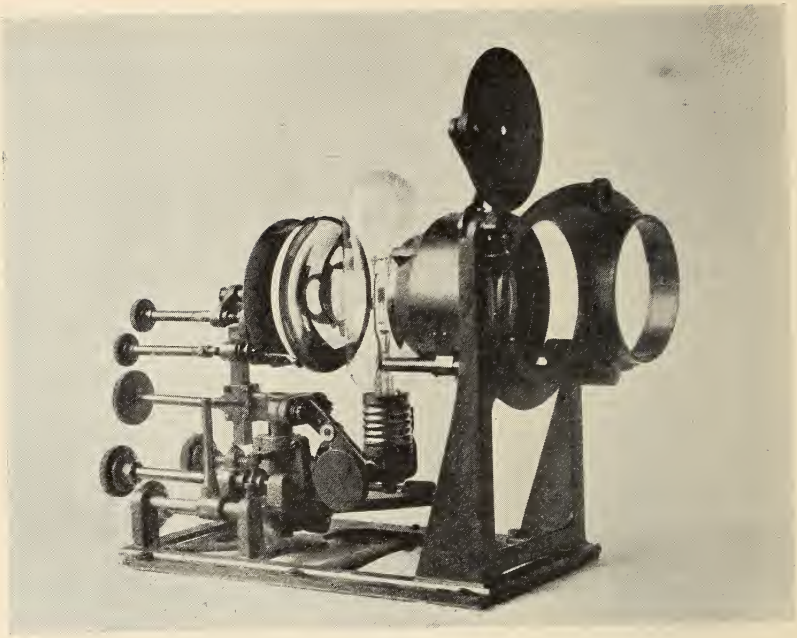


Fig. 3

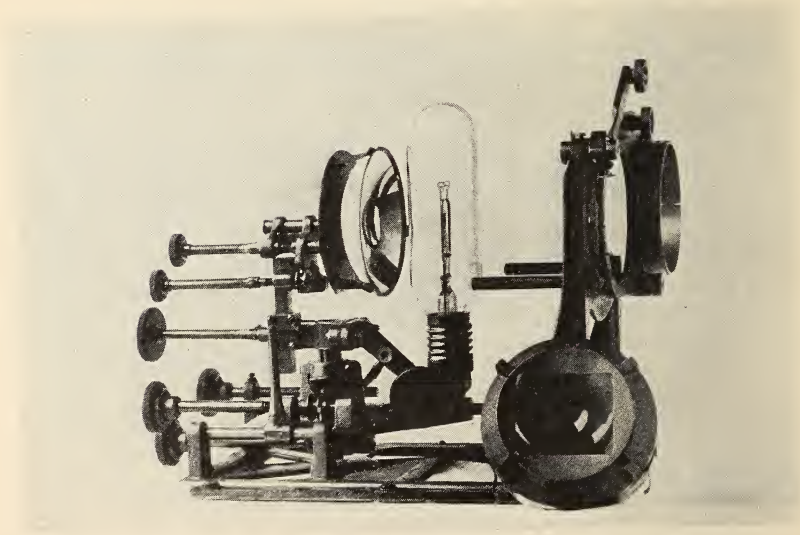


Fig. 4

integral with the support casting. The condenser jackets are interchangeable. It is our custom to provide an additional pair of condensers and jacket with each installation, so that in the event of any trouble with the condensers a new pair may be instantly substituted. Anyone who has ever struggled with a hot condenser will probably appreciate this. We have also found that the probability of a condenser being cleaned is directly proportional to its accessibility. The condenser normally has but two exposed surfaces, but the front and rear elements are of course easily removable from the jacket. Figure 4 shows the condenser jacket removed from the mounting.

Even the dowser has become a part of the optical system, and as such is entitled to a firm foundation. So we have extended the condenser support casting up to include a bearing on which the dowser operates. The "semaphore" on the front of the condenser support casting swings so as to position either opening before the condenser. It is normally fitted with the conventional funnel-shaped light shield over one, and a lantern slide carrier over the other. These were removed to better illustrate the other features of the unit.

I would like to say here that the base casting of the unit is normally much heavier than the one here illustrated, and does not include the adjustable sub-base. A separate base casting is made for each type of machine, no attempt being made at a universal arrangement.

The method by which the correct adjustment of lamp and reflector is determined with ordinary condensers is to place a target on the stereopticon rod at a point parallel to the correct location for the filament image in the objective lens. Instead of the conventional pinhole, the dowser is provided with a ½ inch aperture, so that the condenser is working at about F 7 when the dowser is closed. This gives a brilliant image on the target by which the lamp and reflector may be lined up: and they will be in the correct position *along* the optical axis when their images are *focused sharply* on the target. It is surprising what results can be obtained with ordinary plano convex condensers when the lamp and reflector are focused in this manner, and the arrangement insures exact duplicaton of lamp settings, and consequently uniformly good results upon the screen. The focusing arrangement provided with the special condensing system used in our larger theaters is similar in principle, but the target is on the same axis with the film aperture, so it is not necessary to move the lamphouse in setting the lamp and reflector.

Our unit proved so successful from the very outset in our smaller theaters that we began investigations with a view to increasing its "range," to make it available for installation in our larger theaters. There seemed to be at that time no immediate prospects for more effective lamps, so the only solution was to increase the efficiency of the optical system. We accordingly directed our attention to this field. After some prolonged experiments, in which we were assisted by optical engineers from other Government Departments, we de-

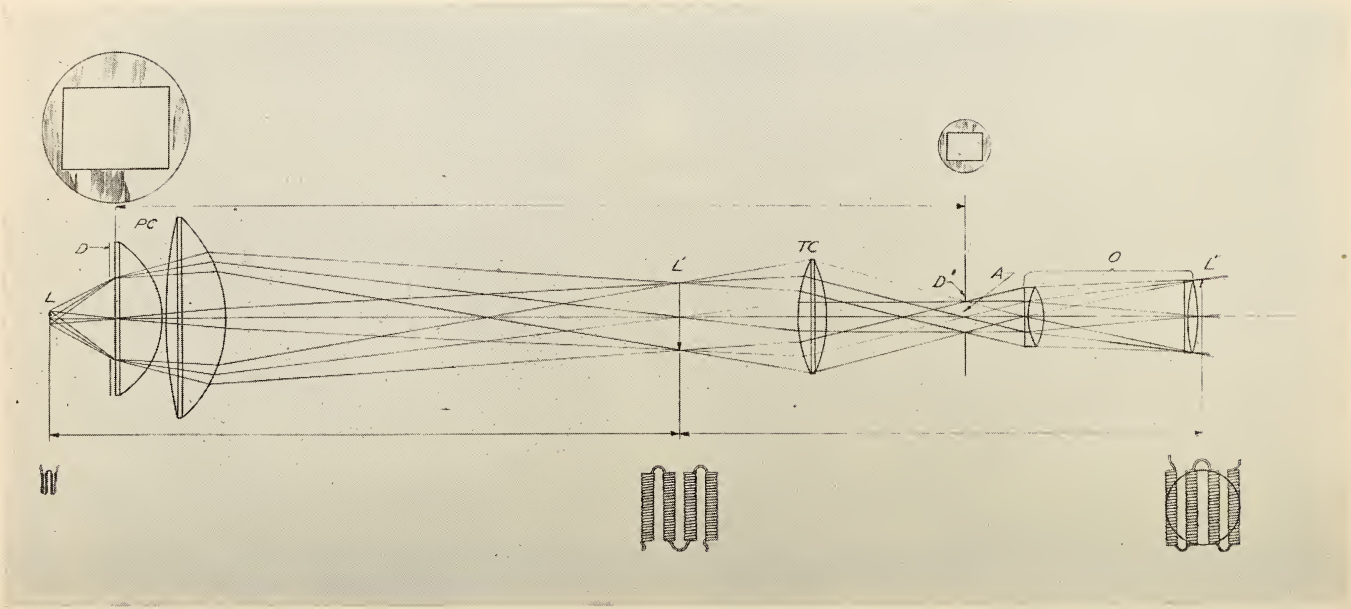


Fig. 5

veloped a condensing system which made it possible to use our incandescent lamp unit with entire success in the largest theaters we have.

In the spring of 1923 we constructed six units embodying the new condensing system and installed them in summer training camps, where the theaters had throws of about 170 feet, and main floor seating capacities averaging 2600. The performance of the units occasioned so much favorable comment that we immediately began the construction of similar units for all our larger theaters, and today practically all of them are operating with this type of apparatus.

As this condensing system is still the most effective of which we have any knowledge, I feel that a full description of it would not be out of place here. We call it a "tandem" condensing system, for it is in reality two condensing systems "in series."

Figure 5 is a diagram of this condensing system. L represents the light source, and L′ its image formed by the primary condenser PC. The tandem condenser TC is placed with its rear focal point coincident with the image L′, and is of such focal length that it co-acts with the primary condenser to image at the film aperture A the field of light immediately behind the primary condenser. A diaphragm D may be placed over the rear of the primary condenser to make a rectangular "spot" on the film (D′). In this respect the system is similar to the relay condenser which has already been described to the society. The placing of the tandem condenser with its rear focal point coincident with the image L′ causes the film to be illuminated with parallel pencils of light, giving a beam beyond the aperture of uniform angular divergence. In the diagram, I have traced the rays from three points on the filament, at the center and at each margin, passing thru three similar points on the rear face of the primary condenser. In this manner the various images are clearly shown, together with the outlines of the condenser beam. O represents the objective, and L″ is an erect image of the light source formed by the tandem condenser and objective. In the diagram, images formed by the various groups are connected by arrows.

Figure 6 is a skeleton set-up of a projector using this condensing system, and shows a photographic record of the condenser beam, together with a diagram of the condensing system, for comparison. The skeleton set-up consists of the unit with its housing, the tandem condenser, a plate carrying a standard film aperture, and an objective lens.

You will notice that this condensing system takes care of the light as far as two very important points are concerned: getting it thru the film aperture, and thru the objective. This is as far as the optical engineer ordinarily considers it necessary to carry it, but there is another factor which must be considered, and that is the rotating shutter. Failure to recognize this has penalized many otherwise excellent condensing arrangements. In the tandem condensing system there are two images of the light source at which the shutter

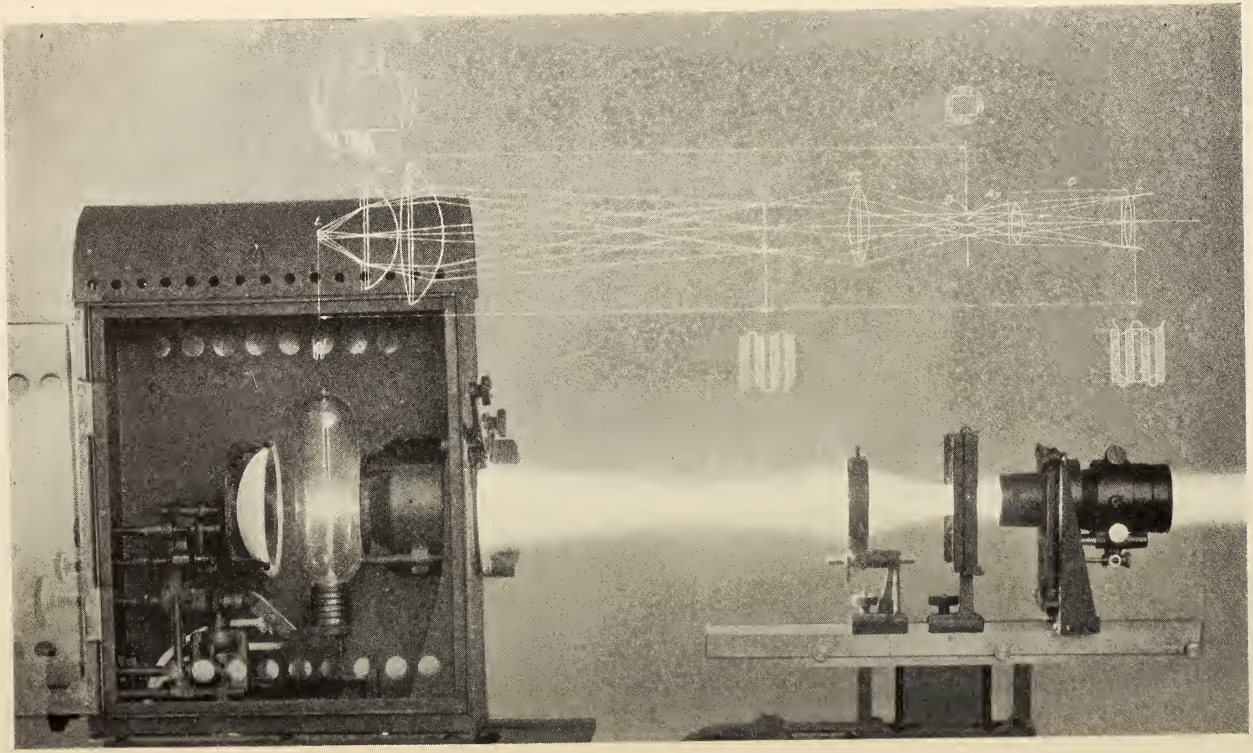


Fig. 6

may be located: one between the first and second condenser groups, and one immediately in front of the objective. A shutter cutting at either point will give a "dissolving" cut-off of the light, and need only equal the actual angular engagement of the intermittent to eliminate travel ghost. Where the shutter is placed at the first of these two images it of course reduces the heat on the film by about half, which is very desirable.

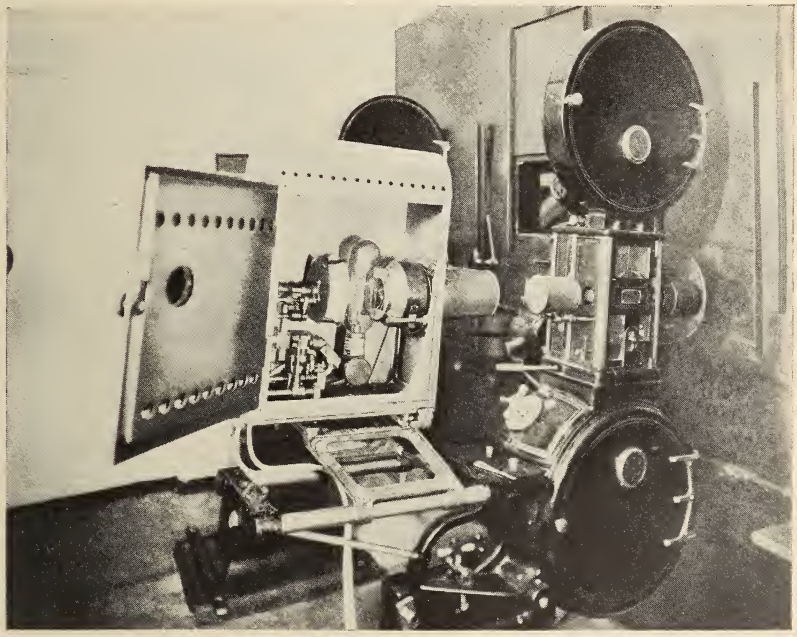


Fig. 7

This condensing system gives very good results with any good objective of large aperture such as is commonly employed for incandescent work. However, we have so far obtained the best results with a special type of objective, which was patented in this country in January of this year (1924).* It has been on the market for some time, and has proven quite popular for general work, but it is particularly suited for use with the tandem condensing system. This is the lens illustrated in figures five and six. It has a short back focus, enabling the rear element to pick up the entire beam and still remain comparatively small: and the rear element has a focal length equal to the overall length of the lens, so that, in combination with the tandem condenser, it forms an erect image of the light source at the

* U. S. Patent No. 1,479,251.

front element, thus reducing the loss of light within the objective tube to the lowest possible amount.

This objective can also be made with a cemented rear element, which is not objectionable with this form of condenser. The cemented construction of course reduces the loss of light from reflection by about 10 per cent, and reduces the secondary images from fifteen to six.

There is no way by which we can escape the fact that the relative aperture of the objective is one of the governing factors in the volume of illumination upon the screen. To obtain the same illumination at long throws as we do at shorter ones, we must first have a condensing

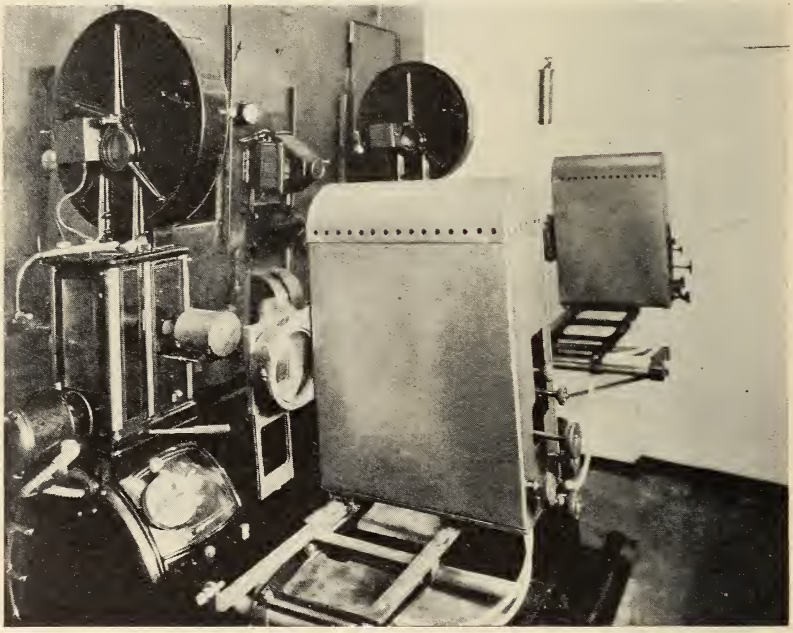


Fig. 8

system giving a fixed angular divergence of the beam beyond the aperture, and second a series of objectives not of uniform diameter, but of uniform RELATIVE APERTURE. The manufacturers of the objective described above were good enough to make for us some special ones having larger apertures for the longer focal lengths. The diameter of the rear combinations of these were somewhat restricted by the present projection machines, as was also the maximum diameter of the front element. But even with these restrictions we were able to go a long way toward maintaining a uniform light flux from the projector without respect to the focal length of the lens. Such a con-

dition would of course mean that we could project an 18 foot picture, for example, with the same brilliancy at 80 or 160 feet.

Failure of the objective to utilize the entire condenser beam, while it results in light loss, does not detract from the evenness of illumination of the screen image.

An unexpected economy was effected by this condensing system in that it prolonged the useful life of the lamps. This seems a peculiar thing for a condenser to do, but it is a fact. The useful life of a lamp is generally terminated by the filament becoming so warped that

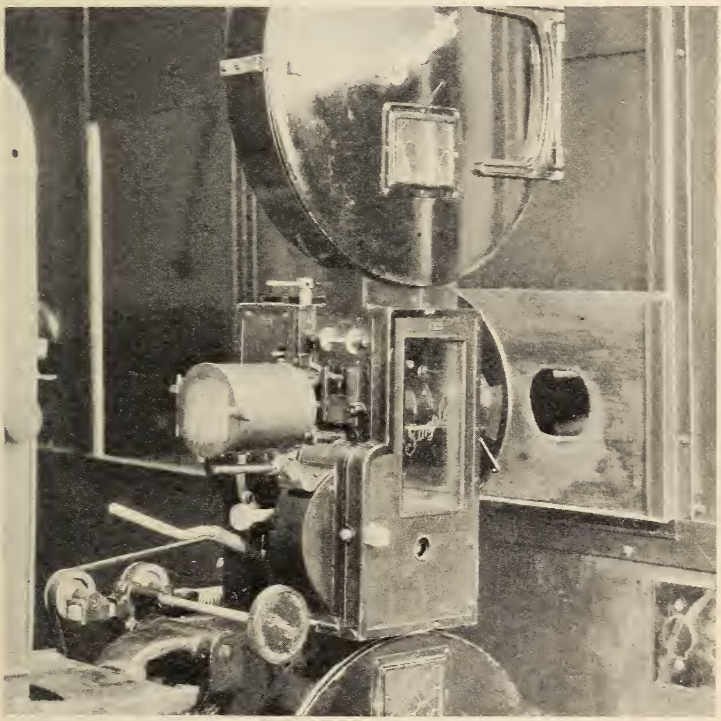


Fig. 9

uniform illumination is impossible. The uniformity of illumination with this condensing system is not affected by the warping of the filament, and as a result it will give good results with lamps which have passed their useful life with ordinary condensers. It is also possible, with this condensing system, to obtain a uniform field of light upon the film without the usual spherical reflector behind the lamp. The omission of this reflector is of course not advocated: it serves to increase the volume of illumination by filling the "gaps" between the filament coils, just as with any other condensing system.

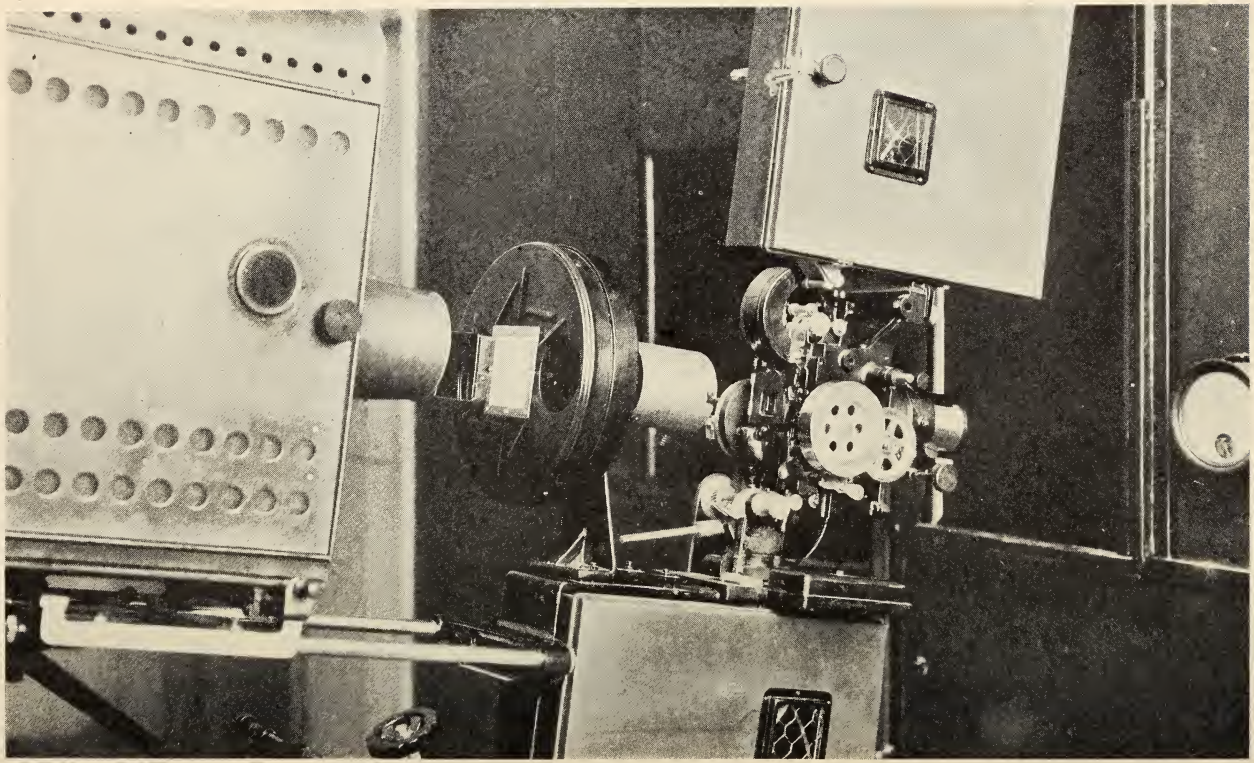


Fig. 10

Figures 7 and 8 are views of the projection room of one of our theaters using the new unit. The projectors are fitted with objectives of eight inch focal length, and the "throw" is 160 feet. These illustrations show the funnel-shaped light shield and the lantern slide carrier, which were omitted in the "close ups" of the unit.

An eyeshield is provided around the tandem condenser to protect the eyes of the projectionist from reflections, and this eyeshield is of such length that its cover falls exactly in the plane of the first image of the light source (L′ figures 5 and 6). This eyeshield cover therefore serves as a wonderful target for lining up the lamp and reflector, and their correct position *along* the optical axis is obtained by focusing sharply on the eyeshield cover. The image on the cover is large, and brilliant enough to be clearly visible even in a well lighted projection room. When the projector is running, there is also an image of the light source visible upon the revolving shutter, and the projectionist can adjust his lamp by means of this, should it become necessary to do so.

Figure 9 is a "close up" of one of the mechanisms in another of our theaters using the new unit. The image of the lamp filament (with reflected image "meshed in") is shown on the eyeshield cover of the tandem condenser. I would like to say here that the popular impression which exists regarding the stationary nature of the light source in incandescent lamps is somewhat in error. We find that the filament is given to slight changes in position which make it advisable to check the setting of both lamp and reflector before every show.

In figure 10 I have illustrated a machine with shutter in the rear. We also use this type of machine with the tandem condenser mounted upon the gate, as in the other types illustrated, but I am showing this as an example of the application of the rear shutter idea. It was of course necessary to revise the mechanism of the machine slightly to get the shutter shaft to the rear. The automatic fire shutter is also incorporated in the rear shutter assembly, and so cuts off the light from the entire mechanism when the machine stops.

In closing I would like to point out that our efforts were not directed to producing a self-operative device, but solely to providing the projectionist with an optical instrument with which he could get the very maximum screen illumination attainable from tungsten filament lamps, and maintain that illumination at all times. Knowledge and intelligence are still essential qualities of the projectionist, and our efforts were directed not toward getting along without these qualities, but to making the most of them.

DISCUSSION

MR. KUNZMANN: Is there any similarity between this condensing system and the Bausch & Lomb relay lens?

MR. HILL: Yes; both get the light through the film by imaging the primary condenser at or near the plane of the film. The difference is in the control of the light beyond the film. We get this by co-action between Tandem condenser and rear combination of the objective. In the Bausch & Lomb relay system, an additional lens is employed, which, I believe, is located at the film aperture.

MR. FARNHAM: Are all those lenses spherical?

MR. HILL: No, the primary condenser is aspheric, and the tandem condenser is a small bi-convex with spherical curves. It is of comparatively short focal length, and at its working distance seems to function very well with spherical curves.

MR. FARNHAM: I notice the large condenser is similar to the Bausch & Lomb aspherical condenser.

MR. HILL: It is.

MR. GRIFFIN: What is the focal length of the tandem lens?

MR. HILL: Three and a half inches.

MR. RICHARDSON: Is this government property or will it be available to the trade?

MR. HILL: I don't know whether it will be available to the trade. Three patents are pending on it and the Government has a license under those patents but the commercial rights belong to the inventor of the apparatus.

MR. STARK: This paper marks one of the few instances in late years where real progress has been made toward developing a more efficient system of illumination.

It would seem logical in view of the fact that the "tandem" lens has an aperture ratio of about f:1, that one correcting or aspheric surface on the lens would make it perform much better.

MR. HILL: It probably would. We are just beginning along that line.

MR. STARK: Mr. Hill made quite a point of the fact that by using a larger pinhole, that is, a hole in the dowser of about ¼ inch in diameter, a much more sensitive arrangement for focusing the light source with respect to the condenser is obtained; but I think something equally important is the proper focusing of the reflector.

MR. HILL: I am glad you brought that out.

MR. STARK: If I may be permitted to make a sketch, I think I could show more clearly what I mean.

The drawing shows a horizontal cross section of a general illuminating system. The solid circles indicate the filaments themselves, and the open circles the filament images as formed by the spherical reflector.

No. 1 shows correct imagery and No. 2 shows incorrect imagery. With the filament images in position No. 1, it is evident that the filament image radiates to the whole condenser, or through the angle "b"; whereas, when the filament images are incorrectly positioned, effective radiation takes place only throuh the smaller angle "a."

If the imagery O′ of the system O takes place through a small aperture on the axis at A_1, it will ordinarily be impossible to say

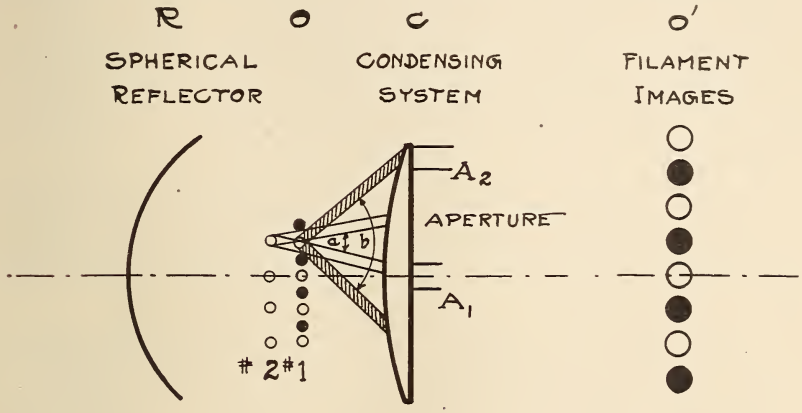


FIG. 1

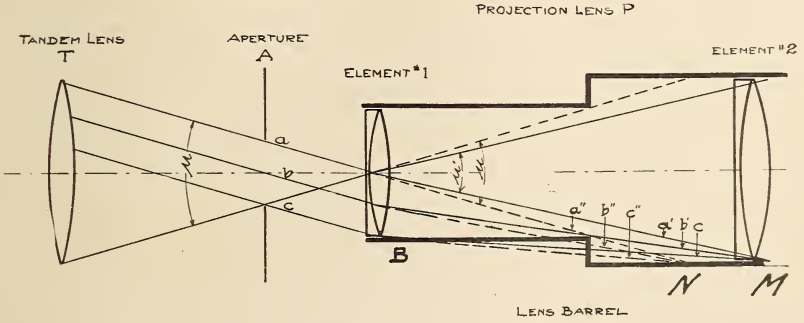


FIG. 2

whether the filament imagery is as in the case No. 1 or case No. 2. However, by putting the aperture at A_2, position No. 1 will give correct imagery at O′, whereas for position No. 2, the reflected images of the filament will be missing. It is evident, then, that by moving the aperture A across the face of the condensing system, and focusing the reflector until the filaments in the image O′ remain meshed for any position of the aperture A, we have a very simple and accurate test

for indicating the correct position of the reflector. I believe that in Madza lamp projection where the available light is so limited, this should be taken care of because it involves very appreciable losses.

I should like to discuss another point for which I would like to have the slide of the projector and diagram of the optical system. (Slide Projected—see Figure No. 6).

The sketch represents that part of Mr. Hill's system to the right of the "tandem" lens which is indicated by T. The aperture is represented by A, and the projection lens by P, each element of which is represented by No. 1 and No. 2. The lens barrel is indicated by B.

The sketch shows three rays—a, b, and c—of one parallel bundle, which are refracted according to Mr. Hill's sketch by the lens No. 1 into the rays a′, b′ and c′ which go to form a point of the filament image at M.

From an optical standpoint, this is incorrectly drawn. The ray "a" is what is known in optical terms as a principal ray of the bundle a, b and c; and is not deviated in passing through lens No.1 as shown in the sketch. Actually, the bundle a, b and c is refracted by the lens No. 1 into the rays a″, b″ and c″ which go to form a point of the filament image at N.

Mr. Hill: The tandem condenser had a focal length of 3-1/2 inches, and the rear combination of the objective a focal length of 4 inches. The magnification would, therefore, be 3-1/2 to 4, and you will find this relation to exist between L′ and L″. However, the drawing was made from observation of these images; we did not draw what we thought ought to occur, but what actually did occur, as indicated by the location and size of the images.

Mr. Stark: I can only repeat that in no optical system can a principal ray such as "a" be deviated in passing through a lens. I think you would have no difficulty in seeing this point if the system were such that full bundles instead of half bundles pass through lens No. 1. In that case the principal or middle ray which corresponds to ray "a" in the sketch would not be deviated. Of course, the primary or large condenser is not a self-luminous object and all that we can get from it through the aperture is a full half bundle of which the ray "a" is undoubtedly the principal ray. In the sketch, there is an angle "u" between the two principal rays "a." The sketch shows that according to Mr. Hill after refraction through lens No. 1, this angle has been decreased somewhat to u′, whereas, according to all laws of optical imagery, the angle between these two rays should remain equal to u, as indicated by the dotted line.

Mr. Hill: I see your point now. There is a deviation of about 3° shown which of course could not occur. However, the thickness of the rear combination is much greater than you have shown, and the displacement of the ray "a" in this lens (which is not shown in either diagram) would be appreciable. We must have drawn the elements of the objective with a slightly greater separation than is

actually the case, for this, together with the displacement which occurs, would account for the apparent error.

Mr. Stark: Mr. Hill has described to us one of several projection lenses which depart from the familiar Petzval type. The advantage to be looked for in a projection lens of such short working distance is its ability to transmit more of the cone of light emerging from the aperture. Due, however, to limitations imposed upon projection lens dimensions by the several standard projector heads on the present day market, this advantage is only apparent and does not really exist. Figure 2 shows that the lens barrel in the neighborhood of the lens element No. 1 is smaller than the lens barrel in the neighborhood of the lens element No. 2. The small diameter of the back portion of the projection lens is made necessary by the fact that it must be used in one of the standard projector heads if it is to be used at all. Figure 2 illustrates the way in which much of the light is lost in the necessarily restricted back portion of the barrel. My own experience has shown that when the mechanical limitations of projectors are taken into consideration, there is no advantage to be gained in employing a projection lens of short working distance.

It may be of interest to state here for reference purposes that A. Koehler described in 1893 (Zeitschrift fur Wissenschaftliche Mikroskopie, Volume X, page 436) an illuminating system as particularly fitted for the projection of microscopic objects. This arrangement is identical with Mr. Hill's condenser now under discussion. An adaptation of this arrangement to the demands for larger field in motion picture projection by the addition of a collective lens near the aperture was made by Koehler in 1915 (see United States Patent No. 1,143,286). The original Koehler system is efficient only when the field is small in comparison with the focal length of the projection lens, as in the case of micro projection; for comparatively large fields, such as in motion picture projection the modified system is much more efficient.[1]

Mr. Hill: I'm glad you brought out the fact that the general plan of imaging the condenser upon the object by means of an additional lens is quite old in optical practice. The use of such an arrangement for motion pictures has doubtless occurred to many, and may have found some usage years ago when objectives of short focal length were the rule rather than the exception. The difficulty with objectives of longer focal length such as are now in general use is the control of the light beyond the film. Koehler's solution of this problem was to place an additional lens at the film aperture. Our solution was to so design the system that the supplementary condenser and rear element of the objective would, in combination, effectively control the light beyond the film, without the assistance of an additional lens in the film aperture. Our system functions in practice precisely

* See paper by Dr. Hermann Kellner "Can the Efficiency of the Present Condensing Systems be Increased?", Transactions S. M. P. E. No. 17, page 133

as it does in theory, but with the Koehler arrangement some compromise must be arrived at, since the aperture lens manifestly cannot be right up against the film where it should be theoretically.

Mr. Porter: I should like to ask what percentage increase in illumination this obtains over the present ones.

Mr. Hill: I had hoped to have a table showing authoritative data on this from an impartial source. The Bureau of Standards was going to make the tests, but we did not get all the condensing systems which were promised us. On the average, we get about two and a half times the illumination with the tandem condenser that we get with our plano-convex equipments under the conditions in our theaters, where the objectives range from 6 to 8 inches in focal length.

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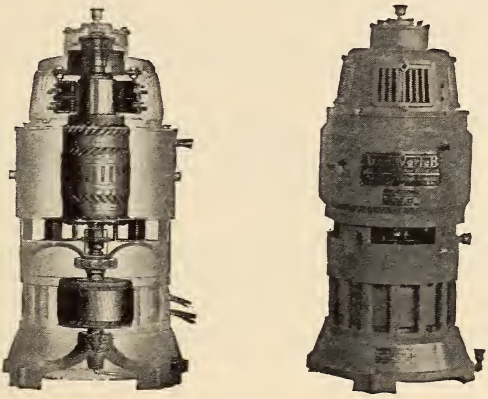

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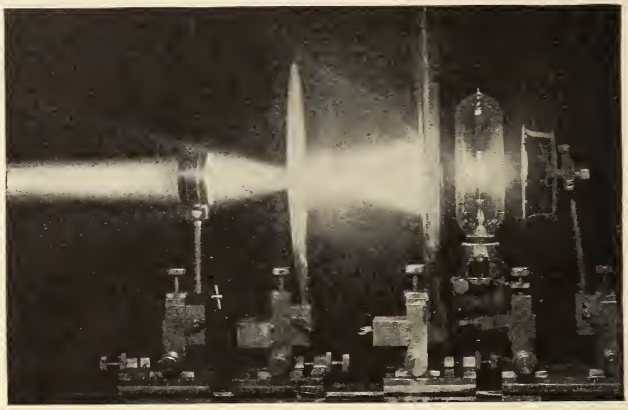
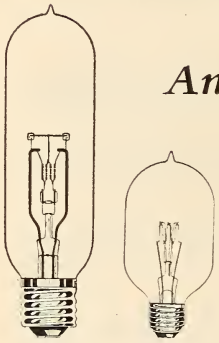


Typical Laboratory Set-Up for Testing Projection Lamps and Apparatus



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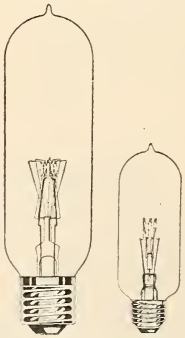

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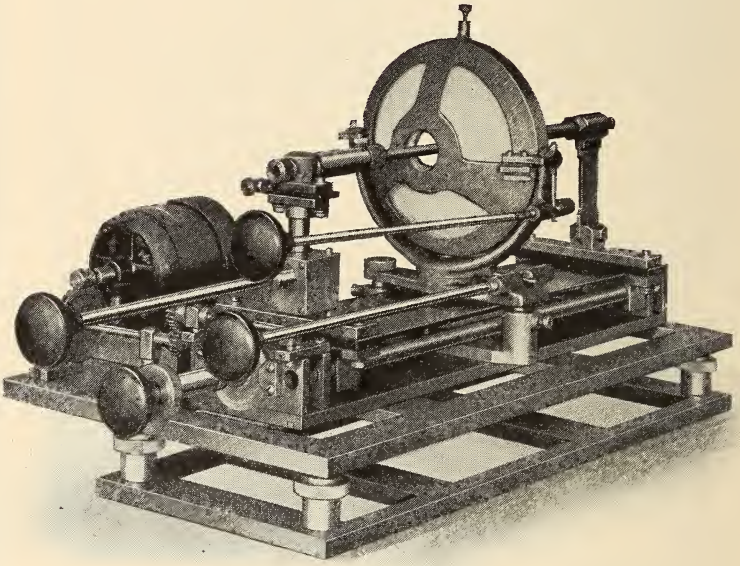

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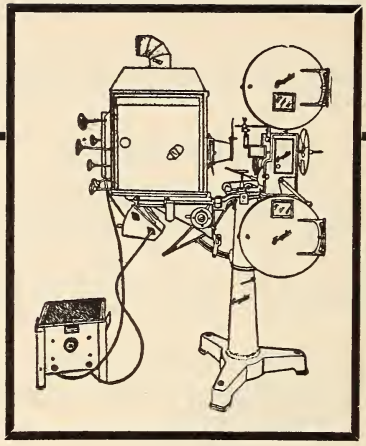

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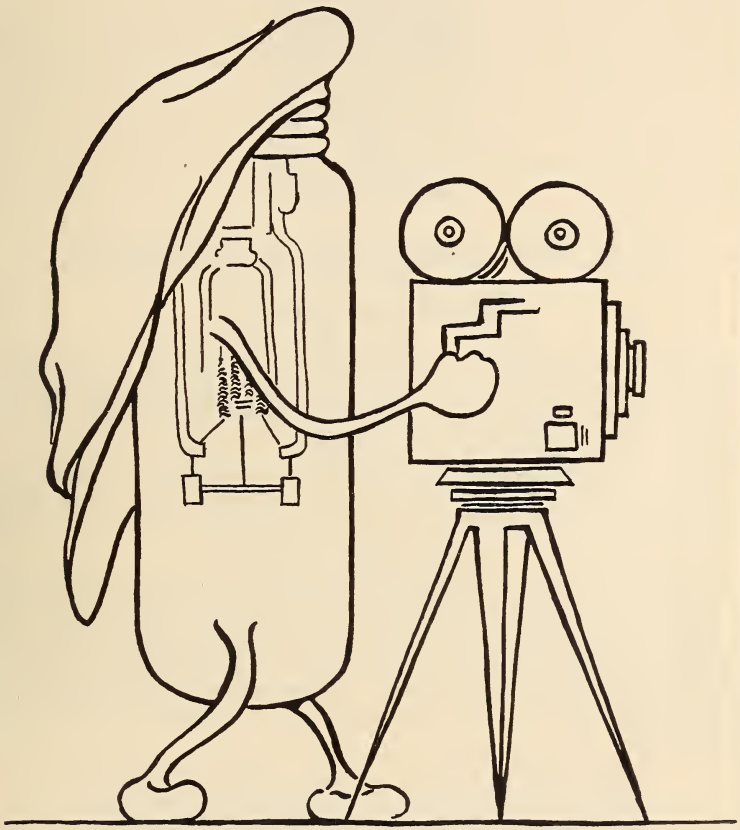

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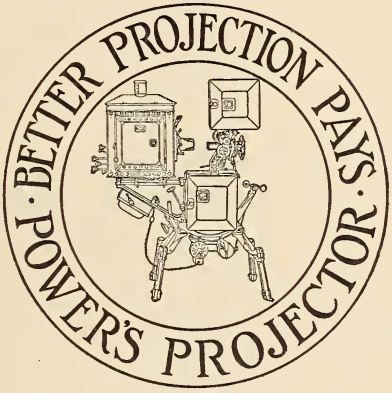

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